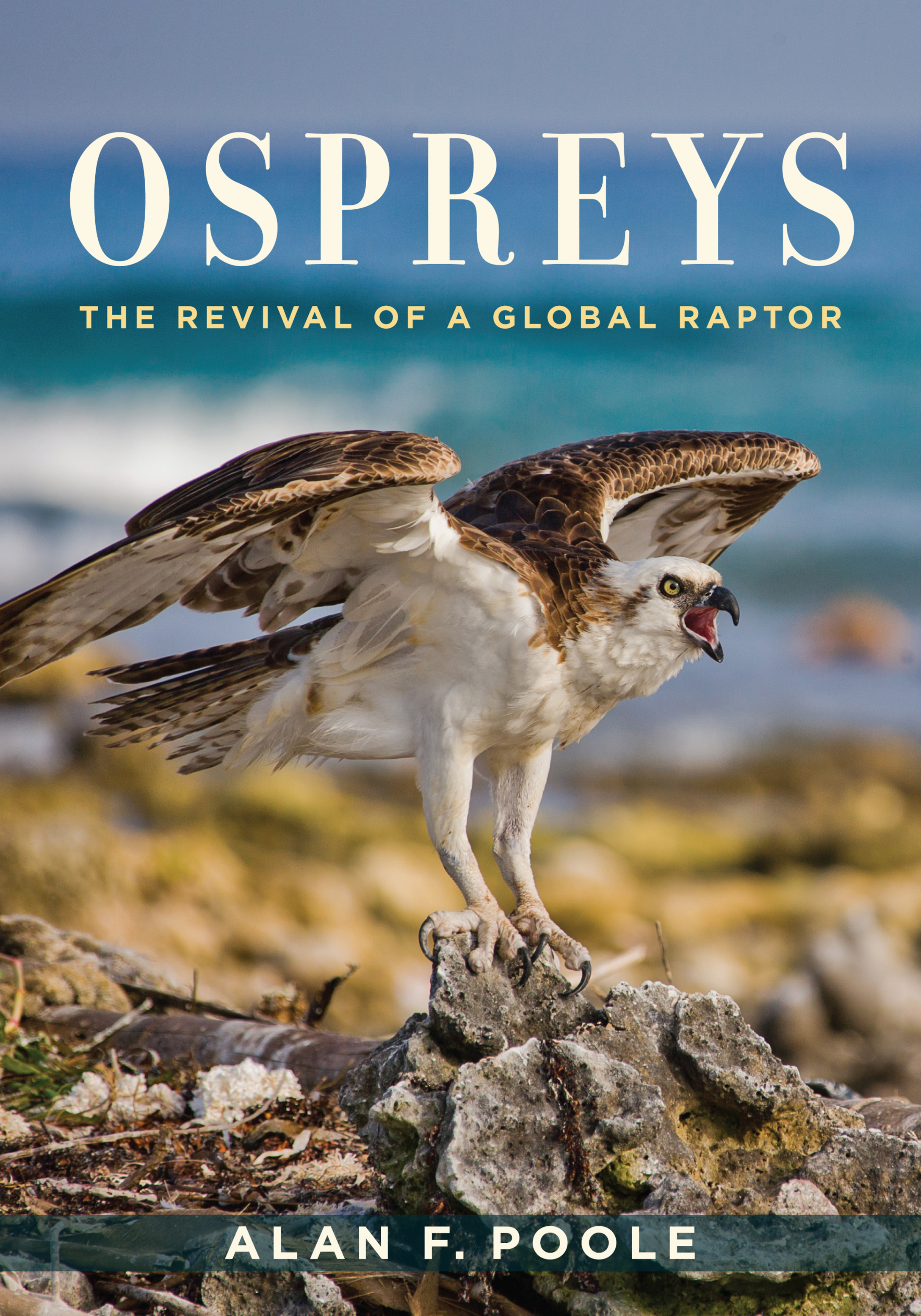
OSPREYS

THE REVIVAL OF A GLOBAL RAPTOR



ALAN F. POOLE

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THE REVIVAL OF A GLOBAL RAPTOR

ALAN F. POOLE

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TO THE OSPREY GARDENERS,
wherever they may be:
those for whom the cultivation
of Ospreys makes the world a better place.
In gratitude for their work
and in the hope that others may carry it on
in the decades ahead.

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Preface

Over the past few years, whenever I told friends and colleagues I was at work on a book about Ospreys, I would often get a quizzical look. "Wait a minute," they'd say, "haven't you already written one?" Indeed I had, a global look at the species published in the late 1980s, so the subtext to their question—why bother with another book?—was a legitimate challenge. Is there really enough new material on Ospreys to visit them again, almost three decades later? Or, the flip side: Aren't you bored with this species and ready for something new?

Yes (double yes!) and no (double no!) are my immediate and respective answers to those two questions. As far as new material goes, the Osprey story has evolved so quickly over the past three decades that in many ways we are now looking at a bird we hardly knew in 1985. Yes, the broad outlines of its biology were in place back then, and its behavior fairly well known, at least at the nest. But we knew almost nothing of its extraordinary migrations or of the wintering ecology of European and North American migrants, tens of thousands of them, that leave their nesting grounds each fall for tropical and subtropical habitats. Thanks to breakthroughs with satellite-tracking technology, starting in the 1990s, we've been able to follow hour-by-hour and even minute-by-minute, the marathon long-distance flights that Ospreys routinely make to and from their wintering grounds each year. That story alone is worth a book.

But there is more, much more. Osprey nests are springing up in parts of the globe where the species has been rare or missing for decades, even centuries. These new nests are bringing palpable excitement to places like England, France, Italy, Spain, and Portugal, to say nothing of many US states in the heartland of North America and portions of the coastline of southeastern Australia—all areas where nesting Ospreys have been absent for generations. And in regions that held only a small handful of breeders in the 1970s and 1980s, we now find robust populations, bursting the seams of their habitat. So a big part of today's Osprey story is the pioneering nature of this species and its resiliency—its ability to recover numbers after setbacks and to adjust to a planet that humans are altering on an unprecedented scale and at unprecedented speed.

Perhaps in part to make up for our sins, humans are helping out with this adjustment. A small but enlightened subset of people are making a real difference in the lives of Ospreys and have been doing so for decades—building nests, managing nest sites and fish farms to prevent Osprey injuries, monitoring populations, and moving young birds to new regions to start new populations. Consider it gardening, ecological gardening. My colleague, Paul Spitzer, speaks of the "Osprey gardens" that he visits in parts of the eastern United States, regions where people have been cultivating the resurgence of Osprey populations for decades—setting up nesting platforms and helping to damp down the crush of human traffic around them.

For me, a big part of the fascination of Ospreys is seeing this gardening urge take hold in different parts of the world, seeing how this bird has been woven into the fabric of various human cultures, and how each supporting culture has a slightly different take on the species. Along with this, getting to know Osprey researchers around the globe, in all their variety, has been one of the great pleasures of my professional career. I'm pleased to be able to spotlight some of them in this book.

Despite the Osprey's broad appeal and near-global range, anyone hoping to learn about new trends and discoveries in the life of this species has been forced to consult a multitude of sources, on the web and in libraries, many of them obscure and hard to find. This book is an attempt to remedy that situation. By distilling key studies of Osprey life history into a single book, and by weaving together the histories and ecology of populations as widely separated as Mexico, Japan, and the Red Sea, I hope to give readers a full and accurate portrait of a bird that is truly a global citizen. If this effort helps spawn new research on Ospreys and inspires others to take a closer look at the bird, I'll feel that my time has been well spent.

In addition, as even a glance at the following pages will show, we now live in a world of very talented wildlife photographers. In just twenty to thirty years, digital photography has opened doors into the lives of birds that earlier photographers were challenged to find. Ospreys are no exception. Subtle wing flexing and intricate course corrections as a diving bird pursues its prey; the delicate presentation of a morsel of fish to a newly hatched young; details of structure and molt in wing feathers of a soaring migrant: all these aspects of Osprey life, and more, can now be seen in glorious color and detail thanks to recent advances in cameras and lenses. One of my goals with a new book on Ospreys has been to showcase the remarkable talent of those who pursue this bird with a camera and to bring glimpses of the grace and elegance of Ospreys to people who may never have seen one up close.

◆

This book was not done in isolation. It is a pleasure to acknowledge the many people who have helped to nurture it. Foremost among these have been my colleagues in the world of Osprey research. Rob Bierregaard helped refine the use of satellite transmitters to track migrant Ospreys and went on to adapt Google Earth maps to show his findings on the web. Without his oversight, his willingness to answer at least a thousand questions, and his brilliant website *OspreyTrax*, I could not have written this book's chapter on migration. In addition, Rob reviewed the entire first draft of this book and made countless helpful suggestions—a debt that will require me to mix many extra martinis for him in the years ahead.

Paul Spitzer introduced me to Ospreys decades ago and has been a ready source of ideas on the species ever since; I remain forever grateful for that. Roy Dennis (Scotland), Pertti Saurola (Finland), Rolf Wahl (France), and Tim Mackrill and his Rutland Water colleagues (UK Midlands) were all gracious, welcoming, and informative hosts on my very enjoyable tour of European Osprey country in the summer of 2016. Daniel Schmitt (Germany), Akiko Shoji (Japan), Terry Dennis (Australia), Flavio Monti (Italy), Luis Palma (Portugal, Cape Verdes), and Miguel Ferrer and Aitor Galarza (Spain) were prompt and willing correspondents on all things Osprey for their respective countries. C. J. Henny, Eric Greene, and Jim Kaiser helped me gain a better understanding of western US Ospreys, birds I hardly knew. And I'm grateful to Mike McMillian for a tour of the exceptionally large and dense Osprey colony that he oversees on Lake Istokpoga, Florida—a glimpse of the species in its prelapsarian splendor.

This book would be much thinner gruel without its photographs. When my call went out for Osprey photos, the response was immediate and overwhelming. I am in debt to countless photographers, but especially to Kris Rowe and Jacob Steinberg of Connecticut, United States; Margaret O'Brien of Western Australia; Craig Gibson of Massachusetts, United States; and John Wright of the United Kingdom. Others who contributed photos used here are Jim Kaiser and Ed Schulz (Oregon, United States), Daniel Schmidt-Rothmund (Germany), Juhani Koivu and Risto Mattila (Finland), and Atsushi Sugiyama (Japan). Thanks to all for generosity. Brooke Keeney got me started on the graphics for this book, and Robert Cronan of Lucidity Information Design LLC appeared in the nick of time to help me go the distance with maps and other graphic elements. And what bird writer could get luckier than to have Julie Zickefoose show up, watercolors in hand, to grace pages with her fine artwork.

No one has expressed the anxieties of book writing better than Herman Melville, in his masterpiece of a novel, *Moby-Dick*: "This whole book is but a draught—nay, but the draught of a draught. Oh, Time, Strength, Cash, and Patience!" Time, strength, cash, patience—at times all were a struggle to find as I labored to complete this book. But I was lucky that cash appeared from a number of key sponsors just when I needed it most. I gratefully acknowledge a major book development grant from the Dalio Foundation (Westport, Connecticut); also welcome help from Lee Linen, Kathi Hatch, Craig Gibson, David Jeffrey, and the Sanibel-Captiva Audubon Society. In addition, Jim Griffith and the International Osprey Foundation were more than generous with time and money; I am especially grateful for the confidence Jim showed in me. The Cornell Lab of Ornithology (Ithaca, New York) and the Westport River Watershed Alliance (Westport, Massachusetts) signed on as not-for-profit fiscal agents in my efforts to raise money for this book. My thanks to both those worthy organizations.

Cornell University's A. R. Mann Library gave me access to 95% of the material I needed while I researched this book; my gratitude is large. In our web-based era, when the value of libraries is increasingly questioned, here's a vote of confidence for what a large university library can bring to the table.

I received strong editorial support from Vince Burke and Tiffany Gasbarrini, at Johns Hopkins University Press, and freelance editor Kathleen Meyer. I'm especially grateful to Vince for having faith in a new Osprey book and for being patient as I completed my manuscript, to Tiffany for guiding me toward more coherent prose, and to Kathleen for finding all the errors that I had missed.

Lastly, I'd like to acknowledge that support comes in many forms, helpful as cash and editors and libraries can be. This book would never have been completed without two inspiring winter homes, sources of sun and warmth and flowers and birds during months that I find bleak and depressing at northern latitudes. Thanks to Black Rock Lodge, Belize (Cam and Kelley Boyd), and the Organization for Tropical Studies' Las Cruces Biological Station, Costa Rica. Black Rock got me started on this effort and Las Cruces provided the quiet, inspiring surroundings that helped me put this book over the top. I remain forever grateful to the Las Cruces crew, especially Rebecca Cole, director, and (last but not least) my delightful yoga students who kept me focused and grounded. To all of the above, namaste.

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ONE

Introduction

This Famed Bird

The habits of this famed bird differ so materially from those of almost all others of its genus, that an accurate description of them cannot fail to be highly interesting to the student of nature.

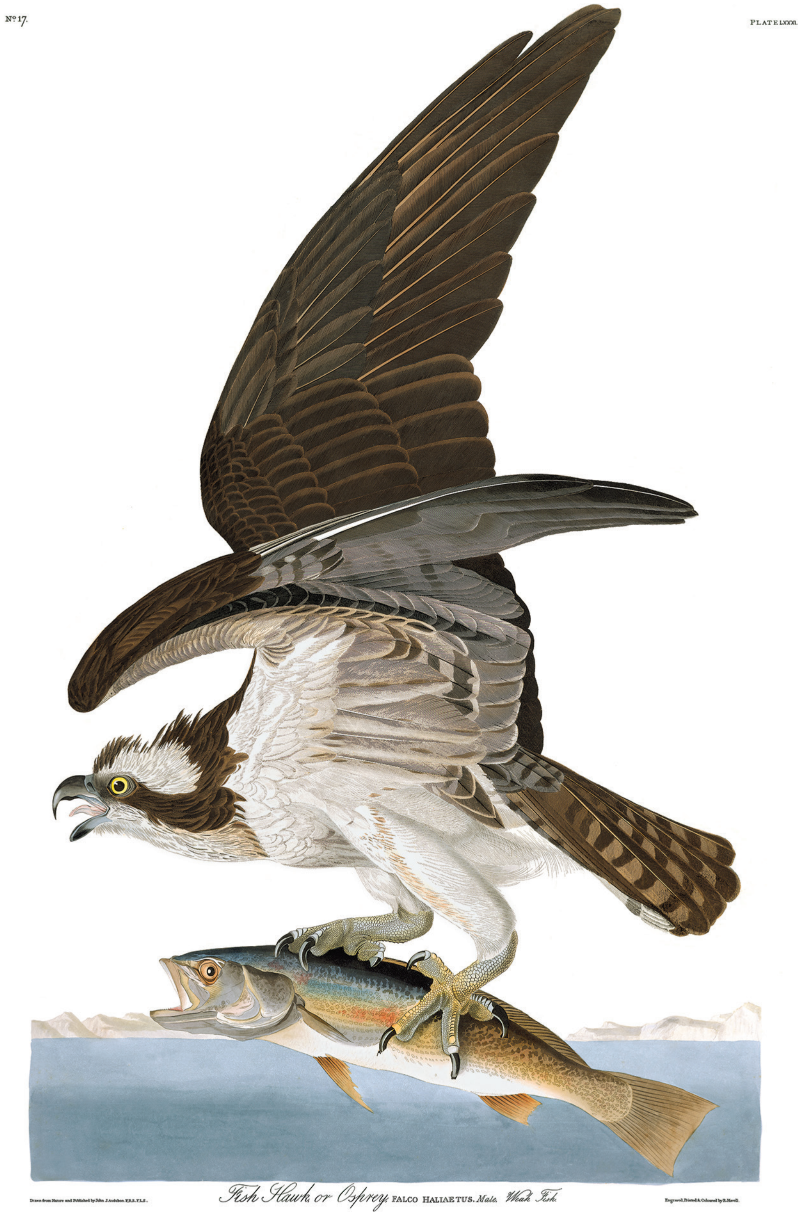
John James Audubon, 1831

A bright May morning dawns over the coastal salt marshes of southern New England. A cool breeze rises off bay waters with the sun beginning to warm the ground and throw glints and sparkles off the gentle tidal chop. I ease off on the throttle of my wooden skiff, letting the bow nose softly up onto the edge of the marsh. The first hints of soft green brighten the new grasses emerging across the impressive sweep of this open landscape, with forested beach dunes and an ocean horizon beyond—a serene slice of wilderness in one of the Osprey heartlands of America.

Looking out over the marshlands, at least two dozen short poles snap into view, each topped with a platform and the large bulk of a round stick nest. Robust silhouettes of Ospreys stand guard beside each one, or sit low incubating eggs, the telltale white head keeping watch over these same landscapes that I call home. Overhead a few Ospreys find the wind and soar in lazy circles, calling occasionally, and my eye catches one lugging a fish back to its nest, the silvery form locked tightly beneath in its curved talons. Here is an Osprey garden laid out before me, the poles and platforms carefully tended by human volunteers to help these birds maximize a yield of eggs and young, and I take a moment to bask in it all, feeling lucky to be a gardener of this famed bird, one of Audubon's favorites.

But right now I am feeling more like a hunter than a gardener. Lifting my binoculars I zero in on a single nest, where I have just set a small wire dome covered with a tangle of fishing line nooses. A design used for centuries by researchers and falconers to capture birds of prey, this trap has proven remarkably effective, as well as reassuringly safe for birds and nests. Soon I see that the Osprey I've targeted has its feet snared in the trap and I point my skiff across the bay to retrieve the bird.

Even though I have done this at least a hundred times before, reaching up over the edge of the nest and grabbing a seasoned adult Osprey by its legs never fails to bring a thrill and a sense of humbled awe. The great wings beating, the fierce yellow eyes fixed on mine, the crest raised in alarm—here is a chance to lay hands on a magnificent wild bird of prey, one that has evolved over millions of


No 17.
PLATE LXXXI.
Drawn from Nature and Published by John J. Audubon, F.R.S. F.L.S.
Fish Hawk or Osprey, FALCO HALIAETUS. Male. Weak Fish.
Engraved, Printed & Coloured by R. Havell.

Portrait of the Osprey (or "Fish Hawk") by John James Audubon, 1831.

"The way of an eagle in the air" (Proverbs 30:19). An adult male Osprey approaching his nest near Perth, Western Australia.

years to fit these landscapes seamlessly. I fold the wings, hood the head, and untangle the feet from the trap. The bird calms quickly and I can get on with the business at hand, getting this Osprey banded so it can be identified in the years ahead. Understanding the ebb and flow of Osprey populations, and the turnover of individuals within them, depends on just such information.

While the scientist in me is intent on getting this bird marked and released, there is another part of me, less well defined, that steps back to absorb what it is that I have in hand, to take in the whole of an Osprey. I sense immense sinewy strength under dense musky plumage, a body that is never living at anything less than peak capacity—its world demands that focus. I admire the long legs, evolved to reach deep under water, and the huge scaly feet, gnarled and stained with blood, hints of fish torn apart for this bird's sustaining diet. And my eye lingers on that stout hooked beak, dark and strong, so well adapted for ripping flesh from skin and skeletons.

I can't help but think of all that this bird has seen, all the places it has flown beyond the boundaries of my own world: Amazon rivers, Caribbean reefs, Cuban reservoirs, Carolina cypress swamps. All those destinations and more are a likely part of its year as it completes its annual migrations, covering vast distances through fickle weather—storms, winds, sheets of rain, dark cool nights, and bright hot days. Here, I realize, is a bird completely at home in its world.

Released, this Osprey powers off in flight, pausing briefly to shake its plumage in midair, and then quickly finds its nest again; now I can relax and get on with my morning. But before leaving the marsh I pause to look around, quietly celebrating what surrounds me. There is a rich tapestry of life here, and Ospreys, lured in by the nesting platforms we have built for them, are at the center of it. It

Taking the plunge: an adult male Osprey goes after his first fish of the day. Connecticut, USA.

Adult female Osprey at her nest, with three nearly full-grown young. Western Australia.

wasn't always this way. Sixty years ago, when childhood vacations gave me summer glimpses of these same marshes, they were largely empty of Ospreys. Their numbers decimated by pesticide poisons in the environment, and nest sites scarce and vulnerable in the small remnant woodlands that remained nearby, Ospreys were rare and threatened birds here. Deliberate efforts by local naturalists brought them back, cultivating the science that helped ban the worst of the pesticides and building the nest sites that helped launch a robust new generation of Ospreys.

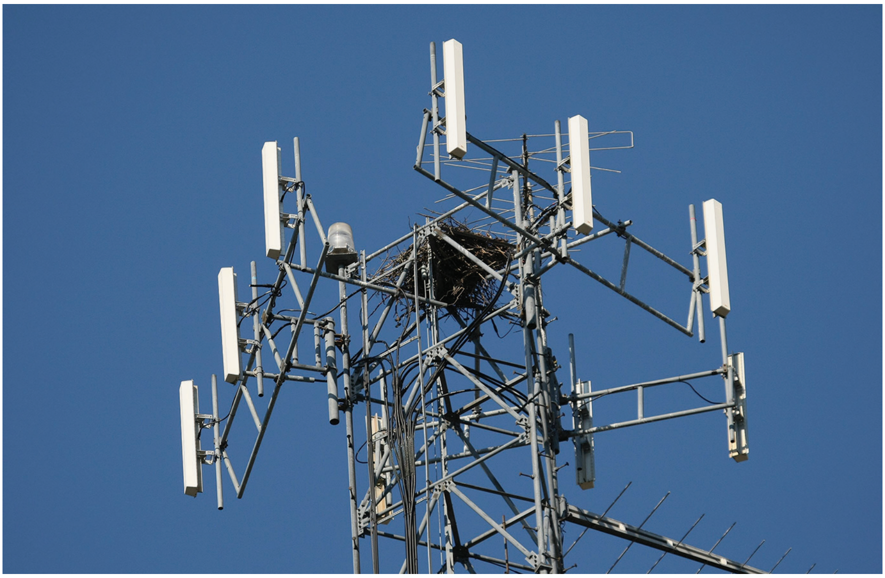
The results we see today are beyond what any of the alarmed and beleaguered conservationists of half a century ago might have imagined. In the past forty years alone, Osprey numbers have surged from about ninety to more than a thousand active nests in the region I've called home—the hundreds of miles of convoluted coastline and nearby islands that stretch between New York City and Boston. Despite an increasingly crowded and degraded planet, we have a survivor.

This local resurgence is hardly an isolated phenomenon. Part of the fascination of this fish-eating hawk is its global reach. From the forests of Hokkaido, Japan, to islands off south Australia, and from Cuban mangrove swamps to Scottish forests, Oregon rivers, and Canadian lakes, we find a species equally at home along a vast array of rivers, lakes, and seacoasts. Many of these populations saw significant setbacks at the same time that Ospreys in the United States did, and earlier. Although the threats that knocked them back differed—mostly guns and traps in Europe and loss of nesting habitat in other parts of the globe—the recoveries came along at much the same time. This renaissance was a reflection of changing attitudes, greening cultures, and the birth of environmentalism, especially in Europe and the Americas, starting in the 1970s.

We caught a break with Ospreys because they were such a receptive and forgiving species, and so amenable to management. Quick to adopt artificial sites for nesting, they were just as quick to adopt new regions when given the chance. Restoration efforts—transferring young before they can fly, and nurturing them in new habitats—have helped reseed areas where Ospreys had long gone missing, from England to Spain to Minnesota. Success in all these efforts was aided by the extraordinary tolerance of this bird, its ability to live side by side with humans, even on the edge of industrial landscapes.

As a result, the species has developed a dedicated following, people intent on promoting its recovery. Consider them Osprey stakeholders. Shoreline retirees in Florida adopt nesting Ospreys as backyard "pets." Finnish and UK bird-banders track down and monitor nests each summer in remote forests. Scottish trout farmers convert fish-filled ponds into meccas for Osprey photographers. Brazilian ecologists study wintering Ospreys on Amazon rivers. And Australian ornithologists scan cliffs from small boats, keeping tabs on nests for decades. All these and more have had a stake in seeing the species thrive, keeping a finger on the

Large eyes promote keen vision, which helps Ospreys spot fish. Adult female, Sweden.



Ospreys have been quick to adopt communications towers as nest sites. Conflicts can arise when such nests interfere with the transmission equipment. Massachusetts, USA.

pulse of Osprey well-being in ways that few would have thought to do a generation ago.

It is this almost universal awareness of the species, its “fame” if you will, that has defined Ospreys since the days of the great bird painter John James Audubon, and before. Living near this bird means (almost inevitably) that one is aware of it:

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Checking the contents of Osprey nests built on artificial sites sometimes requires extreme measures. Electric utility companies such as this one in New Hampshire, USA, have often been willing partners in efforts to build and monitor Osprey nest sites on power poles.

Risto Mattila 2015 ©

Building artificial nests for Ospreys in Finland. Such efforts have helped to stabilize and grow Osprey populations in many parts of the world.

An adult male Osprey returns to his nest with a fish (Atlantic menhaden, *Brevoortia tyrannus*—a key prey species for coastal Ospreys in the eastern United States). Connecticut, USA.

prominent stick nests, sometimes loud with the calls of fledging young; soaring individuals on warm, still afternoons, calling lazily to others below; the drama of a plunging Osprey, the large dark shape emerging from the water with a gleam of silver fish in its talons; and for those lucky enough to live along an Osprey migration route, a stream of the distinctive brown-and-white wings passing overhead on certain days in fall and spring, as the birds vacate one continent for another in their continual search for warmth and fish.

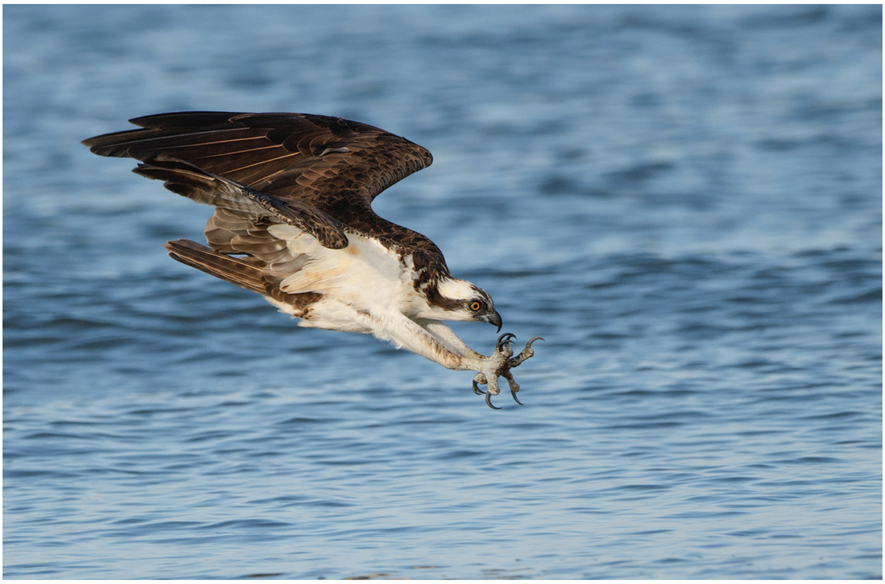
For all of these reasons the Osprey is as famed in our day as it was in Audubon's. What we now know about this bird's history makes it even more compelling. We celebrate its miraculous recovery from contaminants and guns, as well as its restoration to areas where less enlightened people drove it out. We appreciate its ability to serve as a barometer for levels of fish and poisons in our environment. And we stand in awe of its spectacular long-distance migrations, which Audubon knew little about. But in many ways it is the drama of its life, its central place in any habitat that supports it, that lets this great bird reach across time and distance to unite us in admiration. Few birds have had such a hold on the human imagination. This book is a quest to see why this is so.

TWO

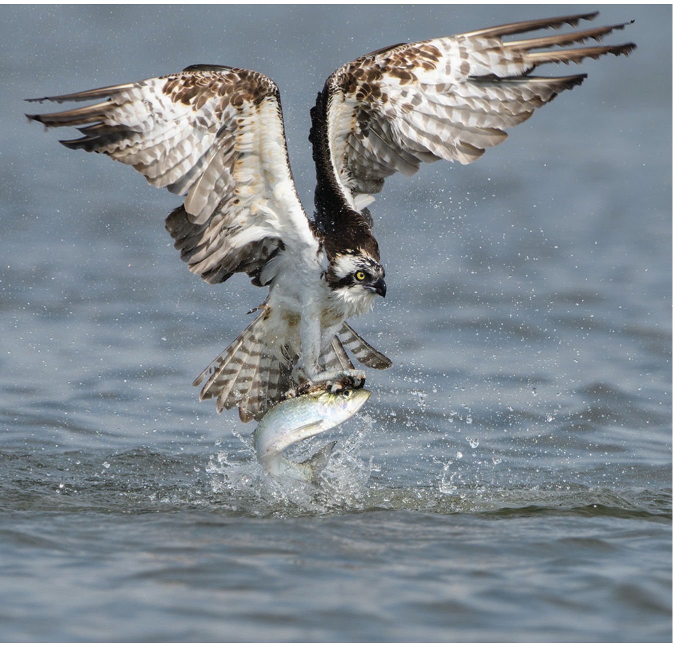
A Hawk That Fishes

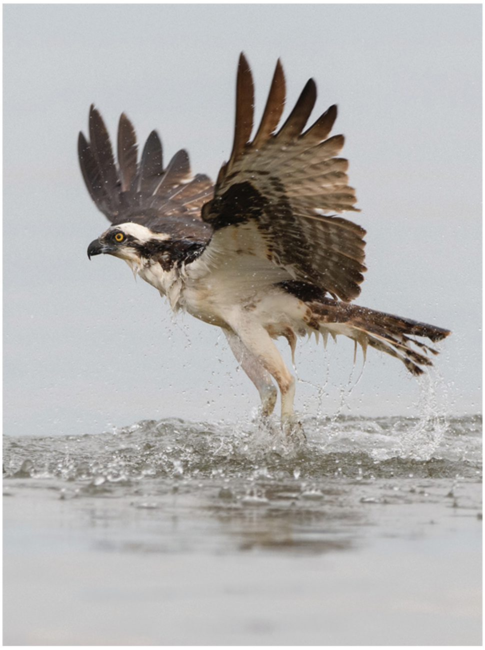
I was a child of about 7 or 8 years old when I saw my first Osprey. I was on a family canoe trip through mountain lakes in the northeastern United States, and my introduction to the species was a dramatic one. I'd grown up in nearby farming country, a region devoid of Ospreys in those years, the late 1950s. But those wilderness lakes I was visiting still sheltered a few breeding pairs, and I was lucky enough to stumble across one of them.

It was shortly after dawn, a bright clear morning in June. My father and I had just launched our canoe and were headed across a lake to a trout stream on the other side. Still sleepy, entranced by a warm breeze and the rhythm of our paddling, I barely noticed a large dark bird flying slowly along the shoreline as we approached, hovering at treetop level and moving on, then hovering again, long legs dangling. Suddenly the bird folded its wings and plunged, feet stretched forward and talons



An Osprey with a fish in its sights. Note the formidable talons spread wide for the strike, the long legs thrust forward to break the water ahead of the body and to reach deep, and the head lined up behind the talons to help guide an accurate strike. Connecticut, USA.





Left: A North American Osprey fishes a Connecticut estuary. Ospreys are the only hawks that depend almost exclusively on a diet of live fish. Despite this restriction, they have colonized a broad array of habitats: ponds, lakes, rivers, and saltwater coasts and estuaries all provide fish within reach of this shallow-diving bird. *Right:* Not all dives produce a fish. Here a Connecticut female emerges from the water after missing her catch.

wide. The lake surface erupted in a shower of spray. Instantly I was awake and riveted. A few seconds later the long dark wings reached high, slowly lifting the bird from the water, a flash of struggling silver in its grip.

I had grown up around field and woodland hawks, so I knew birds of prey, or thought I did. But here was something new, a hawk that fished, fearless of a water plunge. The hawks I knew swooped down on voles and rabbits in fields and chased after birds in woods, rarely if ever getting their feet wet. It was a revelation to find a bird of prey so completely at home in a world of water.

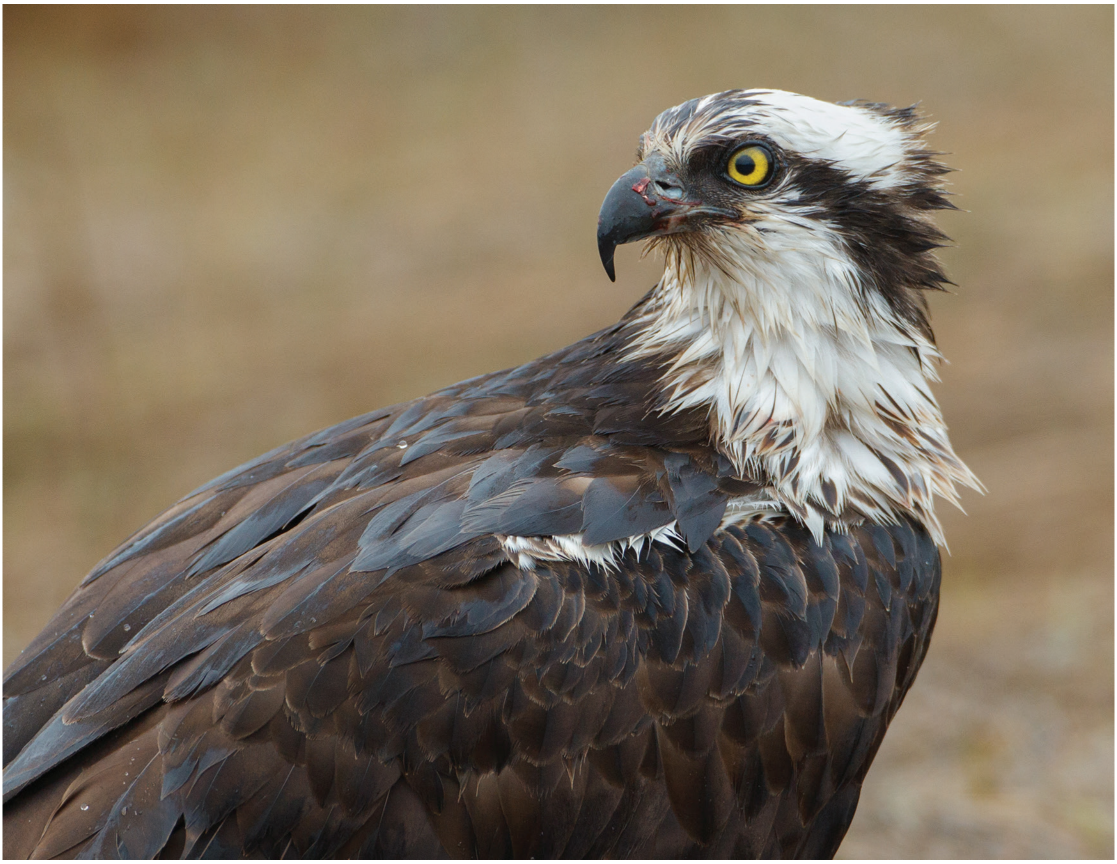
Just how unusual Ospreys are among their close relatives—the hawks and eagles of the world—did not become clear to me until later in life, when I began to study birds, especially birds of prey, in more detail. No other hawk depends so completely on a diet of fish. While many of the “sea eagles” (genus *Haliaeetus*; for instance, the Bald and White-tailed Eagles, and the African Fish Eagle) do take fish, they generally snatch them from the water’s surface or steal them from other birds, including Ospreys. And those birds are just as likely to eat dead carcasses or catch rabbits along woodland edges or ducks or turtles in lakes and marshes. Comparing Ospreys to eagles, Osprey biologists like to joke that no self-respecting Osprey would ever look at carrion unless it were starving—and that’s true. Ospreys are purists, the one and only “fish hawk,” completely dependent on a diet of live fish and superbly adapted to a life of catching and eating them. From an evolutionary standpoint, Ospreys veered off early on a fish track, and that has made all the difference, honing the distinctive features that make this bird what it is today.

SHAPED BY FISH

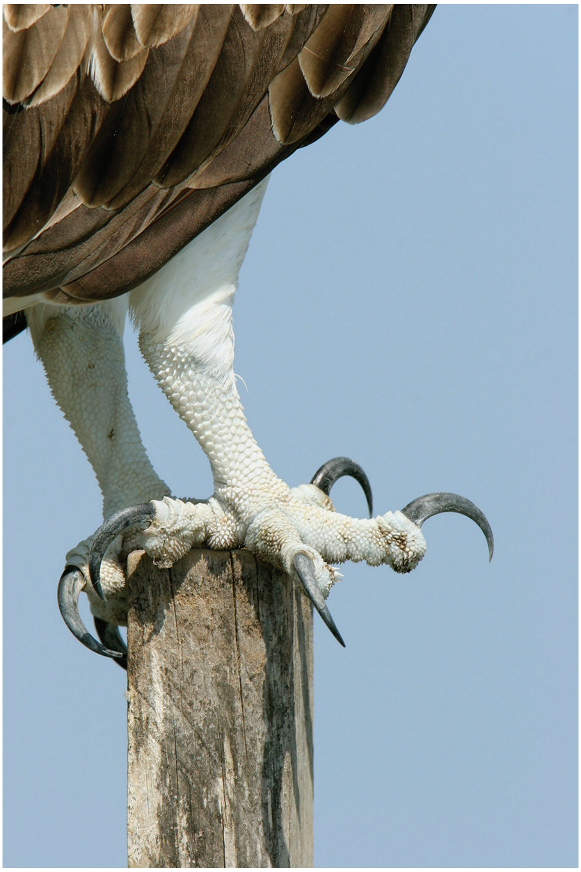
We can learn a lot about Ospreys by noting how similar they are to other birds of prey, as well as how they differ. Open a bird guide to the pages with the hawks and eagles, and a few key findings quickly emerge. One sees that there are separate lineages in this group of birds, and that Ospreys are closely related to the hawks and eagles, all sharing a place in the order Accipitriformes. But taxonomists find that Osprey DNA and their overall structure are different enough to warrant their own separate family (Pandionidae) within that order.

A quick look at Ospreys side-by-side with other birds of prey shows us a bird that shares many typical hawk and eagle features. Among these are large eyes (up to 50% of the skull) that promote keen eyesight (they can resolve details at three to five times the distance that humans can), and sharp, curved talons—a key to securing prey—as well as a short, powerful hooked beak for tearing flesh. And, like most other hawks, Ospreys show what is known as "reversed sexual size dimorphism," a trait in which females are significantly larger and heavier than males, unusual among birds and likely related to the active role that female raptors play in defending nests and in keeping eggs and nestlings warm.

Prominent yellow eyes, a large hooked beak, and dense plumage help define the Osprey. This North American female, an adult, was photographed in a rainstorm so her plumage is slightly wet, but it continues to shed water nonetheless.



The business end of an Osprey. A fish's fate is pretty much sealed once those claws sink into its flesh. The short spines on the bottom of the feet help hold slippery fish.



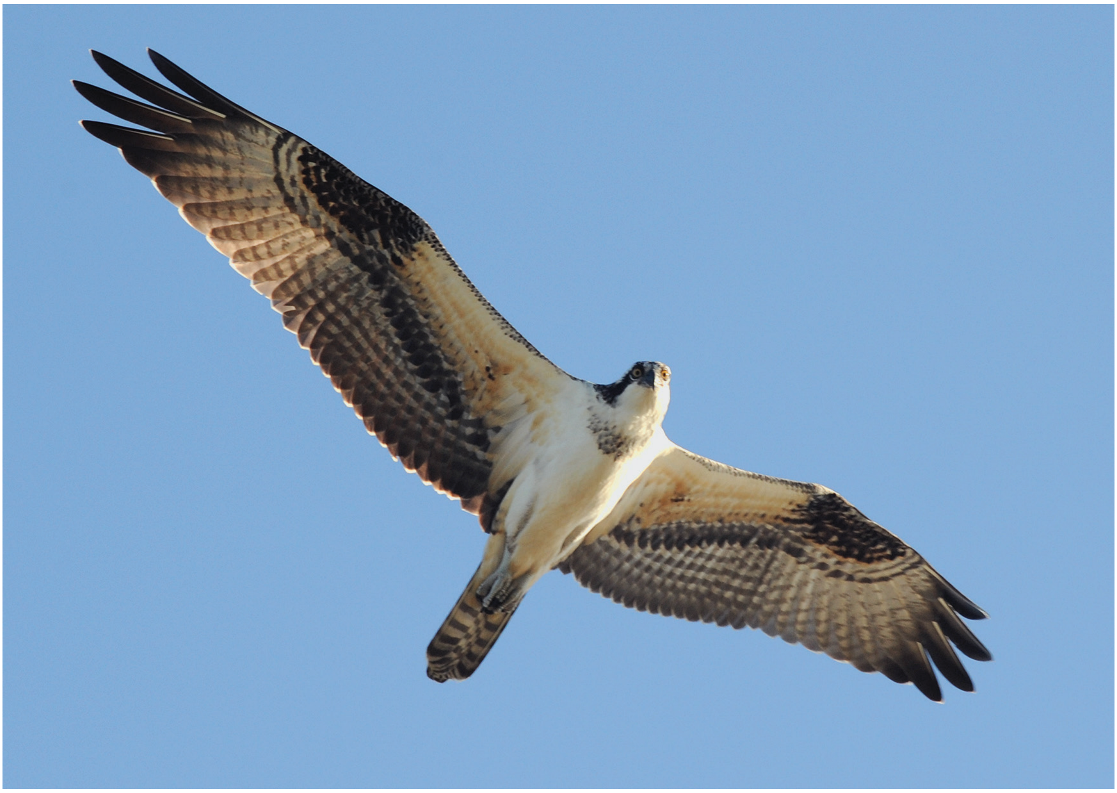
There are many features, however, that set Ospreys apart from other hawks. Ospreys have long legs (tarsi), which allow the bird to reach deep for quick elusive prey. And these legs are mostly bare of feathers, which is not surprising in a species that is continually getting its legs wet and that lives most of its life in temperate climates, where an insulating layer of leg feathers is hardly needed. Osprey talons are especially long, strongly curved, and needle sharp, helping to secure slippery fish, and their feet are extraordinarily strong. When I handle an Osprey, the feet are what I fear most; prying open talons that have locked shut (heaven forbid on an arm or hand) requires pliers and immense strength. In addition, Ospreys have a reversible outer toe that swings back to help hold fish, an especially useful trait in flight—to balance the load with two claws forward and two back. And lastly, a subtle but key adaptation: the bottoms of their feet are covered with short, rough spines, a sandpaperlike advantage in hanging on to a struggling fish.

All these adaptations remind us how fundamentally different fish are from birds or mammals or even lizards and snakes—prey that other hawks depend upon. Try grabbing a fish with your bare hands, fresh from the water and writhing hard, and you will quickly appreciate just what it is that Ospreys must contend with. Fish are surprisingly strong, seemingly out of proportion to their size, and their scales are covered with a slippery layer of mucus. No wonder fishermen have devised mechanical contraptions to hold their prey and Ospreys have evolved even more efficient equipment for doing the same thing.

Osprey plumage feels dense and oily to the touch, an important advantage for a bird that may plunge into water eight to ten times a day. But Ospreys are not immune to the rigors of getting wet. One often sees them perched after a long fishing trip or a rainstorm, droop-winged and drying in the sun. But a dive or two barely wets an Osprey; it seems their feathers can survive immersion better than those of their evolutionary cousins. In addition, like other raptors Ospreys possess a nictitating membrane in each eye, a clear inner lens that snaps across the pupil to clean and protect it. Without that membrane a diving Osprey would be forced to shut its eyes at the moment it hits the water, an obvious disadvantage for a fishing bird. And like many other water birds, Ospreys have membranes that help close off their nares (nostrils) when they dive, reducing the chance of getting a lungful of water. These and other subtle, continuous changes have produced a bird impressively well adapted for taking hard, fast plunges into water after fish.

Wing shape also helps distinguish Ospreys from other birds of prey. Various groups of raptors differ in the profile of their wings, a reflection of how they hunt and migrate. Ospreys have long, narrow wings compared to most other hawks,

Ospreys bathe to clean their plumage and help it retain resiliency to the elements. This nesting female from Western Australia is drying off after bathing along the beach of a nearby estuary.



Osprey wings are long and narrow compared to those of most other diurnal birds of prey. In many ways this shape is a compromise: it allows fairly efficient hovering while searching for fish, soaring flight when conditions permit, and powered flight over long distances. This young North American female was photographed on her first migration south. Orange-reddish eyes and rusty under-wing feathers are clues to the age of this bird, and the broad dark breast band, large head and beak, and full robust belly shape are typical traits of female Ospreys.

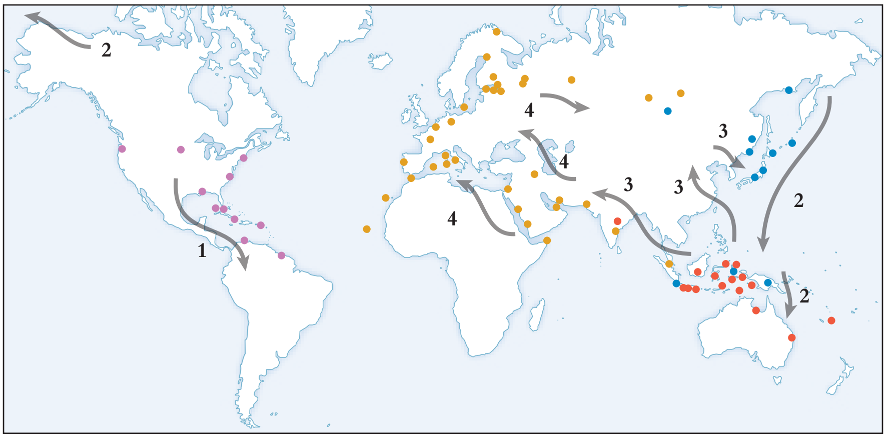
an adaptation for a generally slow hunting mode—flapping, gliding, and hovering over water in much the same way that harrier hawks (genus *Circus*) hunt mice and birds over open plains and meadows. In fact the wings of Ospreys and harriers have a similar shape, and they migrate in much the same way: soaring less than hawks with shorter, broader wings (for instance, genus *Buteo*) and instead using more active and sustained flight to cover long distances, especially over lakes and oceans.

ANCIENT OSPREYS

There is a lot we still don't know about the origins of Ospreys, but the few fossils that have emerged (small pieces: a wing bone, a claw, a beak, and a handful of other skeletal remnants) suggest that by twelve to thirteen million years ago (the mid-Miocene epoch), a bird very much like the Osprey we know today was widespread in North America, the center of origin for this species. From there, genetic evidence suggests the species spread west across the Bering Strait into Asia and Australia, and then on into Europe and Africa—all this more recently, about two to three million years ago.

We may never know for sure about any of this. No fully formed *Archeopteryx*-like fossils exist for our bird, and genetic evidence provides only broad hints about past movements. But it is interesting to speculate on the parallel lives of humans and Ospreys over the course of our own evolution. It seems very likely that Ospreys greeted the first humans as they began to walk upright across the plains of Africa one to two million years ago, and later as our ancestors emigrated north in small bands into Europe and Asia and finally into North America fifteen to twenty millennia ago. No doubt Osprey nests would have dotted the landscapes around our ancestors' camps in those northern regions, and people and Ospreys very likely hunted the same fertile waters. One thinks especially of the vast shoals of sea-run fish moving into coastal rivers in spring, Ospreys and humans alike harvesting a brief but superabundant pulse of welcome food. And it's a good bet that in these early human societies Ospreys were part of nighttime conversations around campfires, woven into myth and culture, much as Ospreys enter the lives and conversations of people who live around them today.

While humans were evolving, so were Ospreys, albeit in subtle ways. A glance at Ospreys today shows us a species widespread in the Northern Hemisphere as well as in Australia and the surrounding Pacific islands but surprisingly similar in size and plumage wherever it lives. The first Vikings stepping ashore in North



Westward spread of Ospreys around the globe during the Pleistocene Epoch, as suggested by genetic evidence assembled by Flavio Monti of Italy. Here we see Ospreys moving from their center of origin in North America (1) through Alaska and across the Bering Strait into Asia, and then south into Indonesia and Australia (2). From there, they spread north again into eastern Asia and Japan (3) and west into Europe, the Middle East, and North Africa (4), filling their current range.

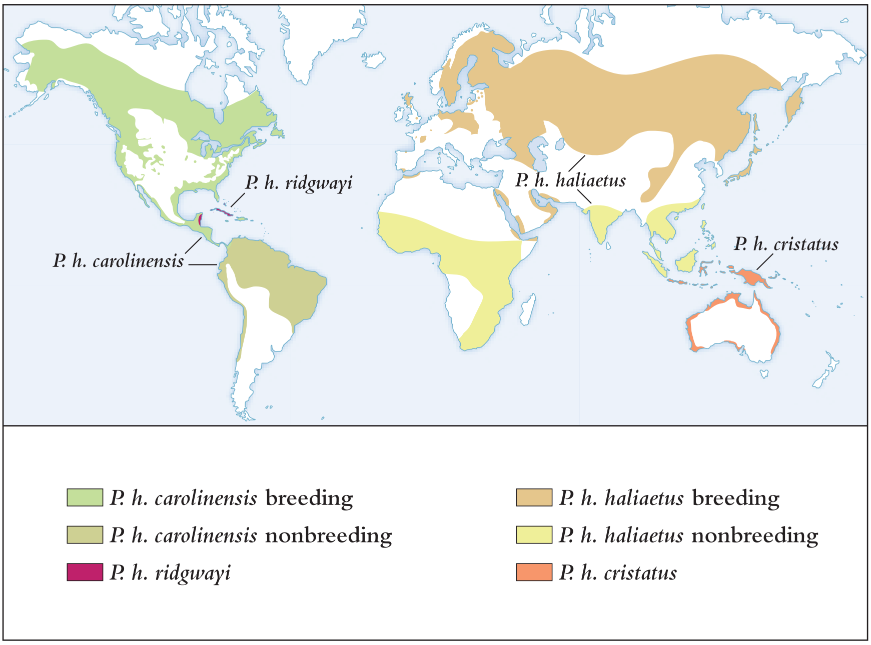
Flavio Monti

EVOLUTION OF OSPREYS IN THE MEDITERRANEAN AND BEYOND

Southern European Ospreys have found a voice in Flavio Monti, a young Italian researcher who has taken the lead in focusing attention on the small, threatened populations of Ospreys that breed on islands in the western Mediterranean Sea: Corsica, the Balearics, and islands off Morocco and Algeria. Flavio grew up in northern Italy and describes his childhood there in charming and vivid terms: "I spent most of my life on the shores of the Mediterranean Sea: cradle of so many civilizations, the Mediterranean region is an interweaving of cultures, colors, and traditions that leave an important mark on those who, like me, had the good fortune to sail its sea, know the voices of its ports, and smell the scents of its islands."

Interested in birds since childhood, Flavio gravitated toward the threatened Ospreys of southern Europe in his university years. Like Odysseus reincarnated as a modern biologist, he decided to make the Mediterranean his focus, and his PhD thesis was a bold and ambitious one. Based at the universities of Montpellier in France and Ferrara in Italy, his research took a close look at the genetics, migration, foraging ecology, and conservation of Mediterranean Ospreys, collaborating with many different people and weaving together varied strands of study to show for the first time that these birds do migrate, some moving locally but some going as far as West Africa; that genetically they are a cohesive group, despite hundreds of miles between subpopulations; and that new populations could be successfully reestablished in this region by moving fledglings from areas with robust breeding numbers to regions where the species had been extirpated. His efforts brought nesting Ospreys back to the shores of Italy for the first time in forty-five years—a small but growing population in Tuscany. And Flavio was ambitious enough to collect genetic material from nearly 225 Ospreys (mostly museum specimens but also some live birds) from thirty-one countries across five continents, running DNA analyses that shed light on the evolution of the species from its earliest origins in North America. Above all he kept a focus on conservation issues, mapping out management plans for the most vulnerable populations in the Mediterranean.

While other researchers have also helped us understand the ecology of Mediterranean Ospreys and the problems they face, Flavio has been alone in his efforts to integrate work on several different populations and on various facets of the ecology and evolution of the species. It is encouraging to think that this integrative approach is the beginning of efforts to fully understand and stabilize this population, and to eventually restore it to historic numbers, numbers that Odysseus and Phoenician sailors would have seen as they crossed the "wine-dark sea."



Global range of the Osprey, *Pandion haliaetus*, by subspecies.

America would have seen Ospreys almost identical to the ones they left behind in Norway. Likewise the ancestors of Australian aborigines floating in on rafts from Asia would almost certainly have recognized the Ospreys they saw nesting along coastlines there.

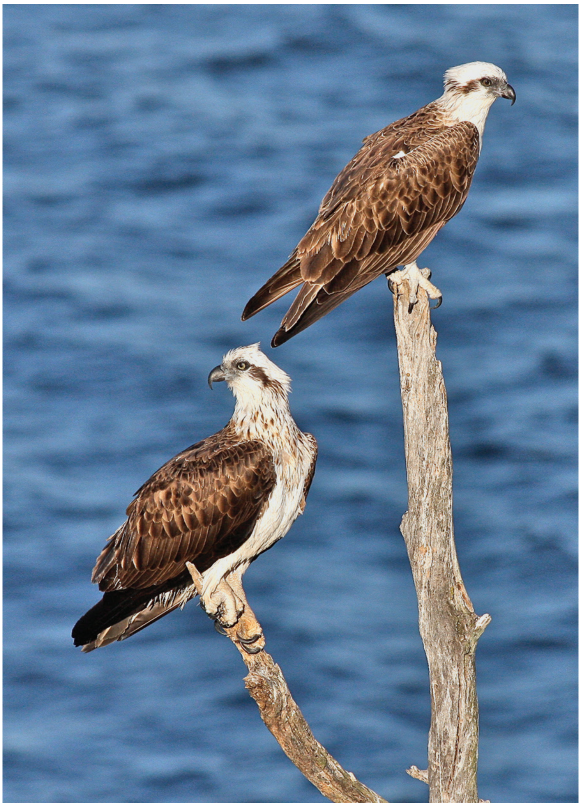
VARIATION: AGE, SEX, AND GEOGRAPHY

But subtle differences in the world's Ospreys do exist, and based on those differences taxonomists have come to recognize four subspecies of Osprey. Before looking at how these subspecies differ, however, it helps to understand the complicating factors of age and sex because even within races Ospreys differ in small but noticeable ways, even though they might look the same to the casual observer.

Young Ospreys—juveniles recently fledged from nests—retain distinctive plumage for the first three to six months of their independent lives, plumage that helps us recognize them at a glance. Pale feather tips on the back and upper wings give these juveniles a slightly mottled appearance, making them easy to spot from a distance. In addition, a rusty yellow wash on the back of the neck and on white feathers of the under wing and sometimes the breast is often noticeable—a feature the adults lack—plus the eye (iris) is a darker orange-red (more red in American Ospreys, more orange in European) than the pale yellow of the adults.

Distinguishing male Ospreys from females can be a little more challenging than separating juveniles from adults. Overall, females are bigger and heavier than males, about 20%–30% greater in body mass and about 10%–15% longer in wing. While these differences do not translate into instant recognition, they do

Adult Australian Ospreys, male (*top*) and female (*bottom*). Larger size and the dark wash on the female's breast and neck help distinguish her from the slimmer, whiter-breasted male. Smaller size, paler heads, and darker breasts help distinguish these *cristatus* Ospreys from their counterparts breeding in the Northern Hemisphere.



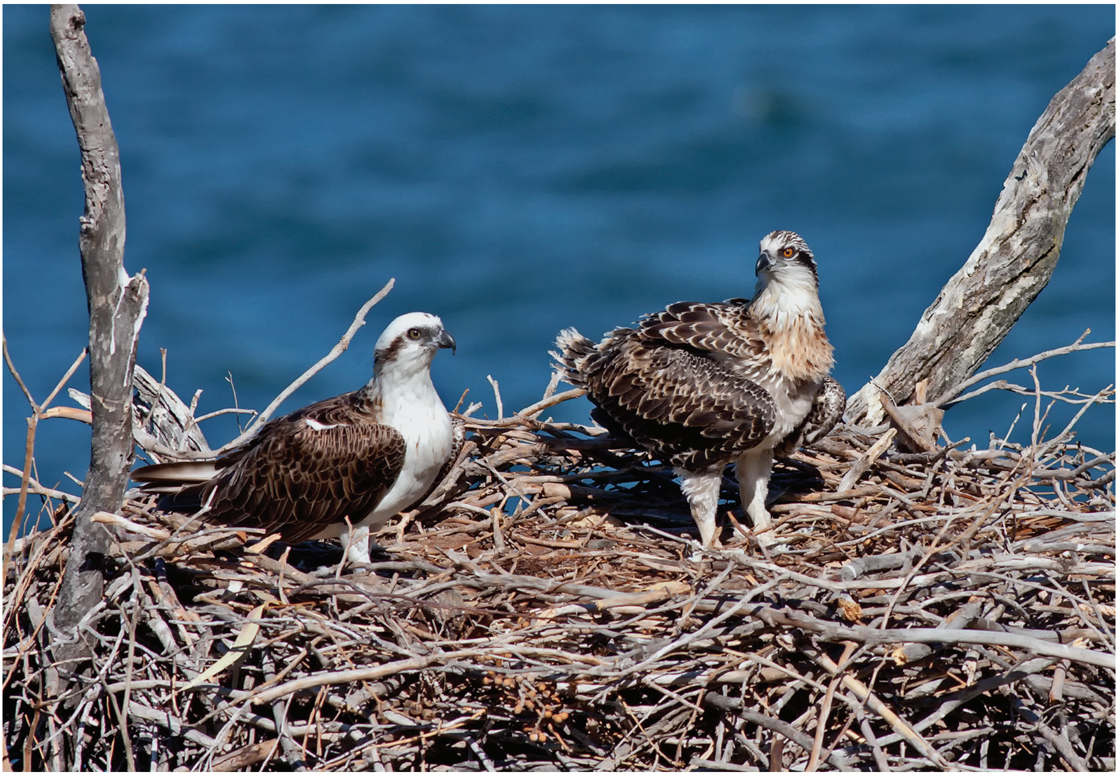
mean that males tend to appear slimmer overall, with smaller heads and feet, and narrower wings. As a result females often seem a bit heavier on the wing (slightly slower, more ponderous flight) than males do. In addition, females tend to have darker, fuller breast bands than males. Especially in North America males are often pure white on the breast, lacking any semblance of a breast band, although there is considerable variation among individuals in this trait. Lastly, seen in flight from below, the under wings of females usually have dark spots on the white feathers of the forewing, which are lacking or much reduced in males.

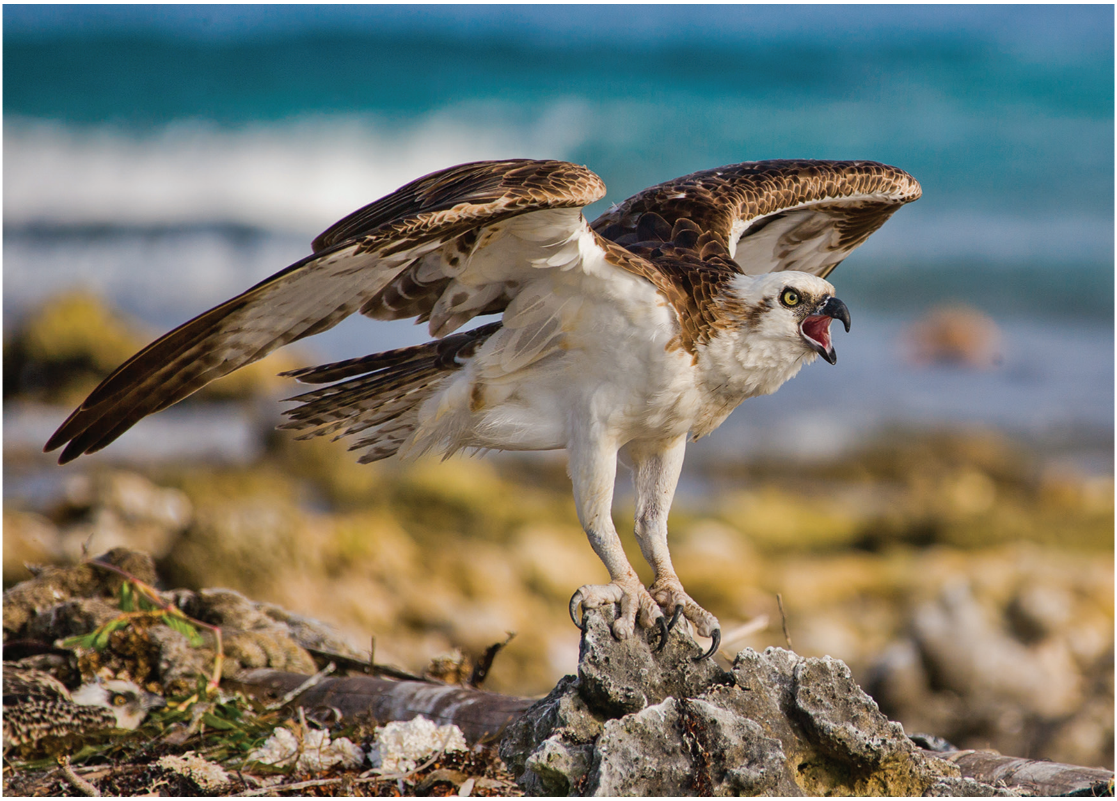
Knowing these age and sex differences helps us look at Ospreys around the globe with a more informed eye. Based mostly on differences in size and plumage, taxonomists have recognized four subspecies of Ospreys: (1) North America's population (*Pandion haliaetus carolinensis*); (2) Europe and northern Asia, from the United Kingdom east to Japan and from Russia south to the Mediterranean and the Gulf of Arabia (*P. h. haliaetus*); (3) a Caribbean Osprey (*P. h. ridgwayi*); and (4) an Osprey of Australia and surrounding Pacific islands (*P. h. cristatus*). Some taxonomists consider *cristatus* distinct enough in plumage and genetics to be its own valid species (the Eastern Osprey), but the vocalizations and behavior of these birds are so similar to other Ospreys of the world, and the genetic data so limited, that there is no reason to think Australian Ospreys would not mate successfully with Ospreys from Canada or France or Florida and produce viable young.

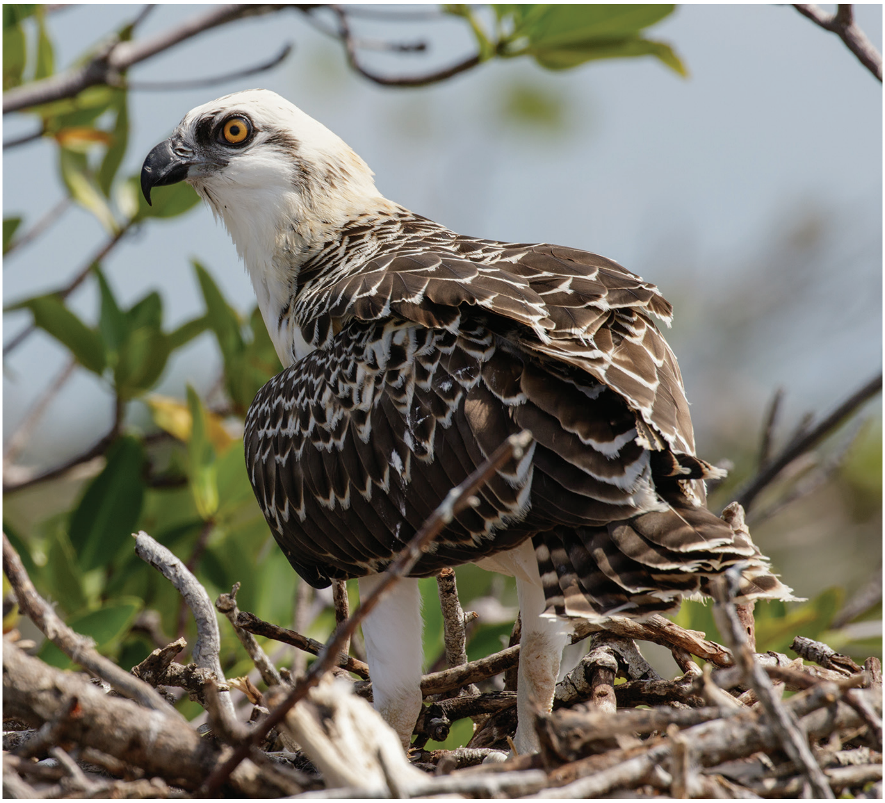
If you could line up a series of these birds, perhaps dried specimens pulled from museum drawers or photos of live birds perched or in flight overhead, you would quickly develop an eye for recognizing these four races of Ospreys. One need not be an especially keen birder to tell at a glance a Caribbean Osprey from its northern counterpart; paler plumage, a whiter head (much reduced black mask—"sin mascara," as the Mexicans put it), and a lack of distinct dark markings on the breast and under wings all set the Caribbean bird apart. In fact, similar but less pronounced differences distinguish populations nesting at lower latitudes in other sunnier and warmer regions—the Baja peninsula of Mexico and the Red Sea and Gulf of Arabia in the Middle East, for example. These differences conform to the so-called Gloger's Rule, which applies to birds in general and stipulates that breeders at warmer, drier, subtropical latitudes tend to be paler in coloration than those at cooler, wetter, and higher latitudes.

North American and European breeders are more difficult to distinguish by eye, but the latter—whether from Japan or Scotland or Corsica—tend to be more mottled with paler brown coloration on their upper parts (American Ospreys tend toward more blackish-brown) and usually have a broader, more extensive dark breast band. In addition, their under wings show more spotting, rather than the

Australian Ospreys at the nest, the male parent (*left*) and a female fledgling (*right*). Like all Ospreys, young of this subspecies have pale tips on the feathers of their back and upper wings. These tips wear off after three to six months, after which the young birds are virtually indistinguishable from adults, except for their fresh, uniform wing and tail feathers.







Top: Caribbean Ospreys have paler plumage and whiter heads than their northern counterparts, although there is considerable variation in plumage within this race. This adult male was photographed along the Belize barrier reef in the western Caribbean. *Bottom:* Juvenile Caribbean Osprey at its nest in Belize.

extensive dark bars that cover the base of the flight feathers in American Ospreys. To the casual observer, it is the large dark breast band that sets the European Ospreys apart, especially the females, with a closer look showing birds with more mottled markings on the under wing.

Naturalists visiting Australia are often quick to note that Ospreys there look smaller than those in Europe or the Americas, and in fact they are. Taking into account sexual differences, we find that wing length, a good measure of body size, is 12%–14% shorter in *cristatus* than in breeders from the northern hemisphere. In addition, Australian Ospreys tend to have a very dark breast band (especially the females) but fewer dark feathers on the head (neck and crown) than their counterparts in northern Europe and the Americas. Overall, the Australasian Osprey is in many ways the most distinctive, perhaps not surprising given its evolutionary history—a remote southern population, well isolated from breeders in the Northern Hemisphere.

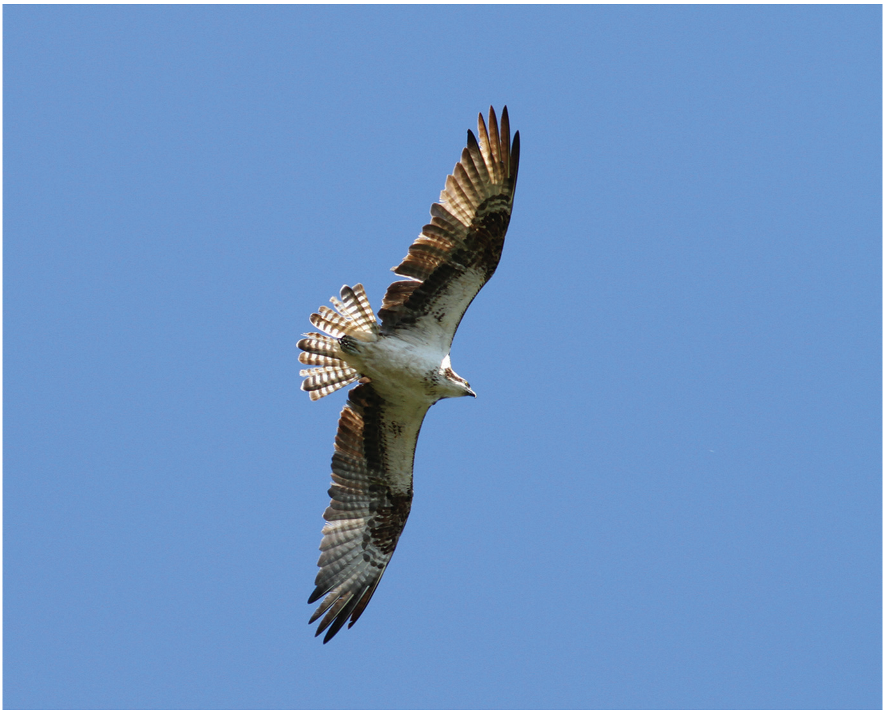
It is interesting to see areas where interchange among subspecies is taking place today, a rare but seemingly regular mixing that helps us understand why Ospreys have retained similarities globally. Caribbean and North American races are known to form pairs and raise viable "hybrid" young in Cuba and south Florida, regions only about 100 miles (160 km) apart. Given such flow, it is hardly surprising that genetic differences have been diluted, even if the Caribbean birds retain their paler plumage. In addition, juvenile Ospreys are known to wander widely, especially on their first migration south. Well-identified juvenile American Ospreys have appeared in recent autumns in Iceland and on islands in the eastern Atlantic (the Azores), at least two-thirds of the way to Europe, individuals likely blown off-course or perhaps having hitched rides on transatlantic shipping vessels. As details of subspecific identification become clearer and more widespread among birdwatchers on both sides of the Atlantic, fall vagrants from the Americas may turn out to be more regular visitors to Europe than we realize.

SHEDDING FEATHERS

Feathers wear out and, like all birds, Ospreys must replace them. Feather molt is one of those hidden aspects in the lives of birds that few people think about, but it turns out to be a surprisingly complex and fascinating subject, especially because it's so critical to keeping a bird alive and functioning at peak capacity. There are intricacies to the timing of molt—variation in how, when, and where individual birds of different ages and sex go about this process—that remind us of how deeply evolution has shaped the lives of Ospreys, or any other bird, for that matter.

One of the side pleasures of keeping tabs on nesting Ospreys, as I do each spring and summer near my home, is picking up and collecting the feathers these birds shed as they follow their nesting cycles. The large wing feathers—the flight feathers—are especially visible, often scattered about on the ground under nests and feeding perches. There are never many of them; Ospreys molt just one or two wing feathers at a time. But pick one up and you are immediately struck by what a marvel of lightness and strength each feather is. Take a closer look and you might see why the bird got rid of it. The edges of shed feathers are usually frayed, the central shaft might be starting to split, and the vanes (the flat, more flexible part of the feather that catches the air with each wingbeat) may look ragged, losing their ability to lock tightly together. In short, sun and bacteria and strenuous use have taken a toll, which is not surprising considering that each feather is a part of a bird for at least a year or two, working to keep it aloft on daily fishing trips and annual migrations spanning thousands of miles.

Ospreys are surprisingly quick to start molting feathers. Four to six months after fledglings leave the nest—the winter after they complete their first migration—they begin to replace at least some of their feathers. Body feathers tend to be shed before flight feathers are, but this varies among individual Ospreys. While flight feathers make foraging and migration possible, body feathers shed rain and retain warmth; they are the bird's rain jacket and windbreaker, all



An adult female American Osprey showing wing and tail that reveal an interesting history of feather molt. Darker feathers are newer, so looking at primaries (the outermost ten wing feathers), we see the youngest feathers at the wingtips, as well as halfway in from there. The lighter-colored primaries are older, likely two to three years old. Similarly in the tail, there appear to be two or three "generations" of feathers, with the lightest-colored ones the oldest.

in one. In no case is a bird significantly incapacitated by molt. Only a few feathers are shed in any one part of the body at any one time. In fact, looking at an Osprey it is usually hard to tell when it is molting, except for its wing and tail. There one sees a few small gaps as the molting bird soars overhead, spots where a single feather has dropped and a new one is starting to regrow in its place.

The sequence of wing and tail feather molt is particularly interesting in Ospreys, as it is in other large birds of prey that depend on soaring flight. Because they need to maintain efficient flight, individuals cannot drop more than one or two flight feathers at a time, and these must be in separate parts of the wing or tail, not close together. In Ospreys it appears that wing molt proceeds in waves, one feather at a time, from the inner primaries (the outermost wing feathers) outward; tail and other wing feathers also follow wavelike patterns.

Ospreys molt feathers only when they can get away with it, when their lives are most sedentary. This is usually during the nonbreeding season on their wintering grounds and, for females, when they are incubating eggs and brooding young at the nest, during which time they are fed by their mates and have no need to forage on their own. During migration it is rare to see an Osprey missing feathers in the wing or tail, just as it is for males during the breeding season, when they are fishing hard every day to feed mates and young. Long-distance flights and efficient foraging require these birds to be flying at peak capacity.

We have no idea how molt is turned on in these birds, and the complexities of molting the right feather at the right time also escape us, but it continues to happen year after year in individual after individual, with remarkable precision. Once settled into a molting period an Osprey might replace one of its tail and wing feathers a month, and each of those large feathers grows slowly, taking at least a month or more before it is fully formed. Because winter is the most protracted molt period for Ospreys breeding in the Northern Hemisphere, when these birds return to nests in spring they have the most intact plumage—looking regal, clean, and trim, ready for the crucial business of producing eggs and young.

LISTENING TO OSPREYS

Although feathers are clearly a big part of what makes an Osprey an Osprey, vocalizations are important as well. You could lose your eyesight and, by simply listening closely, still experience a good bit of the drama that Ospreys bring to the landscapes they inhabit. Not that Ospreys are vocal masters among birds; they have no “song” and they clearly lack the complex repertoire of calls that many parrots and crows have, for example. But they are still a vocal presence. If you live in Osprey country you are likely to hear these birds as often as you see them. For me, the memories of those calls are indelible. I think of faint whistled guard calls reaching across a foggy summer marsh, a distant bird hidden in a shoreline tree. I think of the surprise of sudden, quick alarm calls as I search a forest for elusive nests, a sentinel male warning its mate of my approach. And my spring is not complete without hearing the high, screaming call of a displaying male Osprey in full courtship flight, a distant shape undulating across the sky, a bird I might well have missed without that distinctive sound to alert me.

How do Osprey calls differ and what are they trying to communicate? Although each of their calls tends to vary considerably, with changes in tone and intensity, in essence there are three main types: alarm, begging, and guard, with the male's courtship ("sky-dance") call an offshoot of the most intense alarm calls. People are most likely to hear the alarm call; it's an Osprey's first response to the threat of a person approaching too closely. Other threats elicit the same call: a fox or a dog, for example, coming into view, or an eagle or raven appearing against the sky. Alarm calls may have evolved primarily to alert chicks in the nest to approaching danger. Chicks respond to a parent's alarm by instantly flattening their bodies against the nest, head down, their plumage blending in well with the nest material, helping to hide them, especially from aerial predators like eagles.

The human ear has no trouble recognizing these calls as alarms. They have a staccato, insistent quality to them, starting out as clear, short whistles that fall in pitch and then grade into more excited high-pitched screams as the threat approaches. It's a penetrating call and sounds alarming. Both males and females give these calls, but the male's is higher pitched, as befits the smaller-bodied bird. An alarmed Osprey is also more alert and upright in posture than an undisturbed individual, so if you watch these birds closely you often see their reaction to threats even before you hear them.

Males scream a high-pitched call in their undulating courtship flights, very similar to their most intense alarm calls. So it seems this vocalization may have dual wellsprings, a combination of high stress and excitement that pairs with displaying for mate and rivals, as well as with alerting mate and neighbors to a threat that is closing in.

Guard calls are a warning to other Ospreys, often an individual's first line of defense (especially at the nest) when an Osprey it doesn't recognize is approaching on the wing. To the human ear, these calls sound a bit like a whistling kettle of boiling water taken abruptly off the stove—whistled, down-slurred notes ("tioop-tiioop . . . tiiiioop"), slow and often wavering at the end. If the intruder approaches too closely, the calling often becomes more intense, higher pitched, and quicker, almost a scream, sometimes referred to as the "excited" call. The calling individual seems to be conveying a message to other Ospreys that goes something like this: "I'm here, this nest is taken, stay away. . . ." At the same time that it is calling, a defensive bird often squats low on the nest, with wings extended, helping to cover the nest and likely increasing the intensity of the signal it sends to the intruding bird. As we will see, Osprey nests are a scarce resource with sometimes intense and persistent pressure from intruders—birds seemingly desperate for nests. Successful breeding depends on being able to defend a nest.

It appears likely that Ospreys recognize neighbors by their calls, and perhaps by plumage as well. In the densely packed nesting colonies I study in southern New England, Ospreys almost never give a guard call at the approach of a neighbor—a bird they see every day and presumably know by sight. Instead they reserve those calls for strangers—a bird that might be hunting for a nest site and could be a territorial threat. It always amazes me when watching a cluster of nests, with the birds quietly going about the business of incubating eggs or feeding young, when suddenly a chorus of guard calls erupts. If I strain my eyes I will catch sight of a lone Osprey coming in high and far away. It's a bird I can see well only with binoculars, but these Ospreys have already locked onto it, knowing the bird immediately as a stranger that needs to be warned away. An individual from a neighboring nest would never get that treatment. It is extraordinary what Ospreys can take in at a glance, far more than our humble human eyes can see.

Begging (sometimes called "solicitation") calls are the vocalizations heard most frequently at Osprey nests, but only females and young beg. These are birds that depend on a mate or male parent to feed them, to bring food to the nest. So begging calls are a barometer of the hunger levels of the nest-bound birds. The louder and more insistent the calls, the hungrier the female and her nestlings are likely to be. Late-season nesting colonies are often a chorus of insistent begging calls. This is a time when females are feeding large young, birds that are growing fast and often are hungry, so they beg vociferously. The combination of begging from a female and her offspring sends a clear message of need to any providing mate. Some males are more responsive than others, the laggards perhaps less motivated, or more stressed and at their energetic limits. There is still a lot we don't know about what triggers foraging in male Ospreys, but it seems that begging by dependents is part of the story.

In closing this chapter, we remind ourselves what an unusual niche Ospreys have found among the world's raptors, a niche defined in large part by diet. While very much a hawk, similar in many ways to our planet's other large birds of prey, Ospreys have been shaped in countless ways by their pursuit of fish to the exclusion of all other prey. Subtle differences in plumage and size help to distinguish the four Osprey subspecies, hinting at the potential for speciation in future millennia, but so far these races are all easily recognizable as Ospreys, with complex and interesting molt in all those that have been studied. And, at least to our ears, Ospreys sound like Ospreys the world over, with the same basic calls in all individuals, even though subtle differences likely do exist—differences that Ospreys may recognize and we hope future studies will uncover.

Knowing a little more about the factors that help define an Osprey, we can move on to look in more detail at their geography. Which regions still lack these birds, and why? Where are their numbers most robust? Answers to these questions depend not just on habitat and feeding ecology, which clearly determine an Osprey's ability to colonize an area and raise young, but on human cultures as well. Because, as we'll come to see, people have had a major influence determining Osprey range and numbers, largely to the detriment of the species up until about forty to fifty years ago. Since then, and especially in recent decades, this influence persists but has shifted in a much more positive direction. Ospreys are moving solidly into the twenty-first century, gaining ground and numbers, side-by-side with a great variety of people who, for the most part, are lending a helping hand.

THREE

The Geography of Ospreys

The study of Osprey distribution provides a refresher course in world geography. This is one of just a handful of birds on our planet with a near-global distribution. Scattered across much of the Northern Hemisphere, at least in areas with accessible fish and welcoming places to nest, we find Ospreys incubating eggs and feeding young. And, after breeding, most of these northern birds find winter homes at southern latitudes—Africa, South America, India, and Southeast Asia. Breeders have even made their way to Australia and nearby islands in the Southwest Pacific, the only Ospreys nesting south of the equator. Overall, no continent is foreign to this bird except for bleak Antarctica.

Why is their population so widespread when so many other birds are locked into much smaller ranges? For one thing, Ospreys are long-distance migrants, with juveniles in particular often wandering far off-course. And as we've seen, the species has had a lot of time to wander, especially in the last 100,000 years when glacial advances may have driven them into areas they might never have found otherwise. In addition, this bird is remarkably adaptable in its choice of habitat. At home on both fresh and salt waters, Ospreys manage to raise young deep in the forests of boreal lake country as well as on barren desert islands, rocky seaside cliffs, low mangrove islands in tropical seas, and at chilly northern latitudes as well as under severe desert heat. Clearly these birds have a broad tolerance, and in recent decades this tolerance has extended into the human realm as well, with thousands of nesting pairs taking up residence in heavily developed areas, even semi-industrial ones, thriving alongside the crush of our twenty-first-century civilization.

It is probably fair to say that we know more about where Ospreys live than we do about the geography of almost any other widespread bird on the planet. The information in this chapter attests to countless hours of surveys by people around the globe, hours spent driving and walking back roads and narrow forest tracks, and flying in the cramped seats of small airplanes—all the while peering through

Pertti Saurola and Project Pandion

MONITORING FINNISH OSPREYS

One has to admire the energy of the Finns. Maybe it's the saunas; maybe it's the sour beer they brew to great acclaim; maybe it's their midnight sun. But whatever it is, they seem able to accomplish more, in a shorter period of time, than almost any other nationality on earth. And nowhere is this more evident than in their passion to keep tabs on Ospreys. With almost 1,300 active nests in Finland today, it is a rare nest that goes unmonitored in any year, and that's been the case for decades. And as so often with sustained efforts like this one, there is one person who seems to have made a big difference. And that person, a legend in the world of Osprey research, is the septuagenarian Pertti Saurola.

Pertti has been inspired by birds since his childhood days in Helsinki. Summers spent in the lake country of south-central Finland provided an added bonus for this budding birder, immersing him in a piece of wild Finland still full of cranes and grebes, Ospreys and owls, and forests full of migrant birds. In school, he always found a desk by the window so he could keep an eye on passing birds. By the age of 15, Pertti had his first banding ("ringing") license, along with voluminous notes on the birds he was seeing day to day. Four years studying biology at Helsinki University gave him the training he needed to step into the world of professional ornithology, with one of his first postings at the Finnish National Museum, where he went on to head the Finnish Ringing Group in 1974. His early work with gulls and owls led him to Ospreys, then at risk in northern Europe owing to shooting and pesticides. Sten Österlöf, Sweden's legendary Osprey biologist, encouraged Pertti to take a closer look at Finnish Ospreys. He did that, starting in the mid-1970s, the first time anyone had approached the species there in a systematic way.

So began Project Pandion, which organized bird ringers to find and monitor Osprey nests in Finland. Finland has one of the largest and best-organized banding networks on the globe, and as head of the Finnish Ringing Group Pertti was able to tap into this network, pulling together a cohort of competent people to begin searching Finland for nesting Ospreys. In some ways these nests were needles in a very large haystack, although good birders got smart about finding them in Finland's vast forested stretches. Slowly building and training his crew, Pertti today has more than one hundred people involved in the monitoring, essentially blanketing the country. Few nests now go undetected. Most of the 1,300 nests are visited at least twice a season, to determine whether eggs are laid and whether young have fledged. Considering the size of Finland—about 210,000 square miles (338,000 km^2)—this is far from a trivial task. In fact, among bird monitoring schemes worldwide, this is one of the most ambitious.

A big part of Pertti's efforts revolved around trying to reverse the debilitating effects of industrial forestry on Ospreys and other tree-nesting birds of prey in Finland. Forestry is big business there. Ospreys and Ural Owls, another bird of interest to Pertti, were particularly hard hit as large trees were cut. Pertti's focus was to mark and protect trees that the birds used for nesting, and (along with his team of monitors) to build artificial nests (boxes for the owls, platforms for Ospreys) in areas

where natural nests were scarce. Both projects made a big difference, with more than 50% of Finland's Ospreys now nesting on artificial platforms, most installed in the cut-off tops of trees.

As Ospreys became a bigger part of Pertti's life, he sat down one winter (and winters are long in Finland) and wrote a book on the Finnish population: *Sääksi* (the Finnish word for Osprey). It was a labor of love, filled with stunning photos by the great Finnish bird photographer Juhani Koivu. Winning several awards in Finland, and selling well, the proceeds from its sales were used to start the Finnish Osprey Foundation, which has helped promote Ospreys and Osprey research in Finland, in part through the Pohtiolampi Osprey Center, an old trout farm where visitors can see Ospreys catch fish and learn about how and where the bird nests in Finland.

Pertti's influence has extended well beyond Finland. He is an accomplished linguist, which has helped him communicate about his work throughout the Baltic countries and beyond. In addition to his native Finnish, Pertti speaks and writes excellent English and Swedish and is able to read German, Norwegian, and Danish literature, besides having a passable understanding of Spanish. He even manages an effective dialogue with Estonian colleagues with a combination of Estonian and Finnish.

But in many ways his true and universal language is music. Pertti's mother was a star of the Finnish opera, and she conveyed her love of music to her son. Pertti has sung classical music with a famed Finnish men's chorale for thirty-plus years, giving concerts around the world. One of the delights of international ornithological conferences for me are the evening get-togethers, usually over a few beers, when Pertti is likely to break into song—a hymn or an aria—bringing a momentary hush to the scientific crowd.

Among colleagues, Pertti is distinguished by his aquiline face, a shock of white hair and beard, and a famed ability to climb trees. Now well into his seventies, he still climbs trees, often high ones, to inspect Osprey nests and band the young. A Russian colleague describes him well: "Pertti seems to maintain the true essence of a taiga inhabitant—honest, close to nature, giving the impression of a man just descended from the trees still covered in moss and lichen—one of ornithology's truly colorful characters."

binoculars and telescopes at distant nests. Such is the power of this species to captivate us, for increasingly survey results are arriving thanks to an emerging group of people known as "citizen scientists." Lacking degrees in wildlife sciences but making up for this with keen enthusiasm and good training, these people have played a key role in keeping our finger on the pulse of Osprey populations worldwide. Nowhere is this more evident than in Finland, where nearly all of its over 1,200 nests have been monitored annually for decades by a dedicated group of volunteers, coordinated by the Finnish Osprey Foundation. Similar efforts in Scotland and England, and in a few regions of North America, have been almost as thorough and long-lived. Ospreys have a faithful following and we see the fruits of this labor in the sections that follow.

How many Ospreys are alive in the world today? Although the accuracy of estimates varies greatly across the range of the species, a reasonable total for the global population is about 50,000 breeding pairs. Add to these 100,000 individuals the so-called floaters—birds that are too young to breed, or that are older but remain unable to find a nest or mate—and you might bring another 25,000–35,000 individuals to the total. This is surely a conservative estimate; future studies should help to refine these numbers, probably upward. But key to an accurate assessment of Osprey populations is realizing how lopsided the distribution of this species is. As we see in the sections that follow, just a few countries hold the vast majority of the world's Ospreys. Eliminate the Ospreys of Sweden and the eastern half of North America, for example, and you've lost about 70% of the world population. So while over 130,000 Ospreys may seem like a robust world population, and in many ways it is, we need to remember that most of the globe still holds tenuous numbers of the species.

JAPAN AND EASTERN ASIA

Little is known about the Ospreys of eastern Asia, particularly the remote regions of the Russian Far East (such as Kamchatka) and the Southwest Pacific. Asian Ospreys have been best studied in Japan, a nation where science is encouraged and interest in wildlife runs deep. Here, research has focused on the less-developed northern island of Hokkaido, where surveys by Akiko Shoji and Atsushi Sugiyama found loose concentrations of breeders, sixty to seventy pairs in all. Pairs nest along the coast—dramatic nests on steep cliffs and rocky outcrops—as well as inland atop forest pines. Osprey distribution in Hokkaido seems at least partially controlled by competition with the larger, aggressive White-tailed Eagle (*Haliaeetus albicilla*), which Ospreys tend to avoid because that species steals their fish and sometimes kills their nestlings.

Farther south in more settled regions of Japan, we know much less about our bird, but at least fifteen nests were discovered in 2002 in eastern Kagawa Prefecture, an island off the southeast coast of Japan that boasts dramatic rocky shorelines

Typical Osprey nest along the cliffs of Hokkaido, in northern Japan. Hokkaido pairs also nest inland atop forest trees.

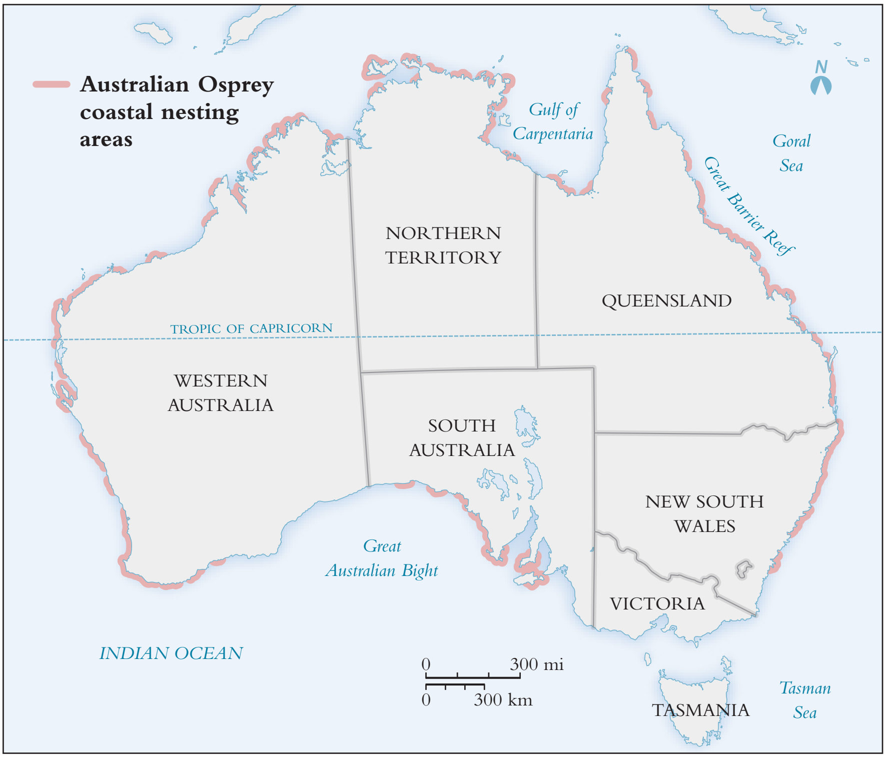
and considerable areas of protected parkland. Keep in mind that Japan encompasses more than 2,400 islands (and many islets), many uninhabited, with a total coastline of almost 18,000 miles (29,000 km), so there is a lot of potential Osprey breeding habitat there. But Japan remains a nation with many fishermen and fishpond owners, few of whom are likely to look kindly on Ospreys in their neighborhood. Shooting and trapping could well be issues there, but at this point we can only guess what their impacts really are.

While we do know that Ospreys breeding in the northern two-thirds of Japan are migratory, it is not clear if those in the southern islands are. And there is no information on where Japanese Ospreys spend the winter. Most, it seems likely, fly to the coasts and rivers of Southeast Asia (Vietnam, Cambodia, Malaysia, and perhaps northern Sumatra), as well as the Philippines; northern *haliaetus* Ospreys are seen in all these locales during northern winter months, October through March, although there have been no band recoveries to confirm their origins.

One wonders if there isn't a role for citizen scientists to survey Ospreys in Japan. The country has deep cultural roots in wildlife, an active ornithological society, and dedicated groups of wildlife photographers. Surely there are ways to harness this interest to learn more about how Ospreys are faring in Japan.

AUSTRALIA AND NEARBY PACIFIC ISLANDS

On the Australian continent we find an anomaly: the only Ospreys breeding south of the equator. This may be an offshoot from Pleistocene times, with populations pushed south by colder weather that accompanied glacial advances. For those of


Australian Osprey coastal nesting areas
Gulf of Carpentaria
N
Goral Sea
Great Barrier Reef
NORTHERN TERRITORY
QUEENSLAND
TROPIC OF CAPRICORN
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
Great Australian Bight
VICTORIA
INDIAN OCEAN
0
300 mi
0
300 km
TASMANIA
Tasman Sea

Breeding range of Ospreys (*P. h. cristatus*) in Australia.

us in the Northern Hemisphere the climatic belts in Australia seem "upside down"—with warm tropical and subtropical regions in the north, where Ospreys are numerous, and cooler, more temperate regions in the south, where Ospreys are more sparsely distributed. Much of the Australian landscape is dry scrub and desert, with few permanent inland lakes or rivers, so Osprey nesting is confined to saltwater coastlines, including estuaries up to their tidal limit. Overall, estimates suggest about 1,500 pairs may breed in Australia, but only a few regions have been carefully surveyed so this number awaits refinement.

Along the coast of Australia's Northern Territory, the species is scarce in mangrove and mudflat habitats where high tidal ranges dominate, with breeding more concentrated along the northwestern coast and on islands in the Gulf of Carpenteria. Numbers increase five- to ten-fold along the tropical, rugged, semidesert coastline of Western Australia, with perhaps five hundred to a thousand pairs in this region. But overall we find few if any real concentrations in this area, with nests on average at least 10 to 15 miles (16–24 km) apart.

There are interesting gaps in the distribution of Australian Ospreys. The species is absent from southeastern portions of the continent (Tasmania, Victoria, and neighboring coastlines), where cold ocean currents make surface fish scarce, and from southern portions of vast Western Australia, where similar restrictions may apply. The only portion of the south coast that is hospitable to Ospreys is in

South Australia, where the Great Australian Bight traps warmer waters—fish thrive there and are accessible, and shallow-water bays abound.

South Australia surveys led by Terry Dennis provide some of the best data for Ospreys on the continent. Overall numbers are small in this region (fifty-five to sixty-five nesting pairs in total), with most territories on the mainland coast and on near-shore islets and reefs. The Eyre Peninsula and Kangaroo Island appear to be Osprey strongholds, holding about 60% of this population. Most nests are on broken sections of coastal cliffs and near-shore rock stacks. Here again, density is low, with a mean distance between nests of about 12 miles (19 km). Surveys show fairly stable numbers, suggesting that Ospreys can deal with the low-level development and tourist disturbance found there, and with a resident *Haliaeetus* eagle—the nesting White-bellied Sea-Eagle (*Haliaeetus leucogaster*).

We find Australian Ospreys thriving along the warmer east coast of the continent, in Queensland (250–500 pairs) and New South Wales (NSW) (130–150 pairs), with populations there growing quickly in recent decades. Increased availability of nesting platforms and a better informed human population (reduced persecution; coordination with utility companies concerning nests on power poles) are factors that seem to be driving the population expansion in NSW, with 30%–40% of the birds nesting on artificial sites. But warming currents may be helping as well. Ospreys now breed at least 500 miles (800 km) farther south along the

Ospreys in Western Australia often nest on cliffs or find an offshore rock like this one. Throughout the world, overwater sites are a favored place for Ospreys to nest because they offer openness, isolation, and protection from predators.

coast of NSW than they did twenty years ago, with a ten-fold increase in breeding pairs in this same period—oceans once again telling us that global climates are changing and Ospreys proving once more how adaptable they can be.

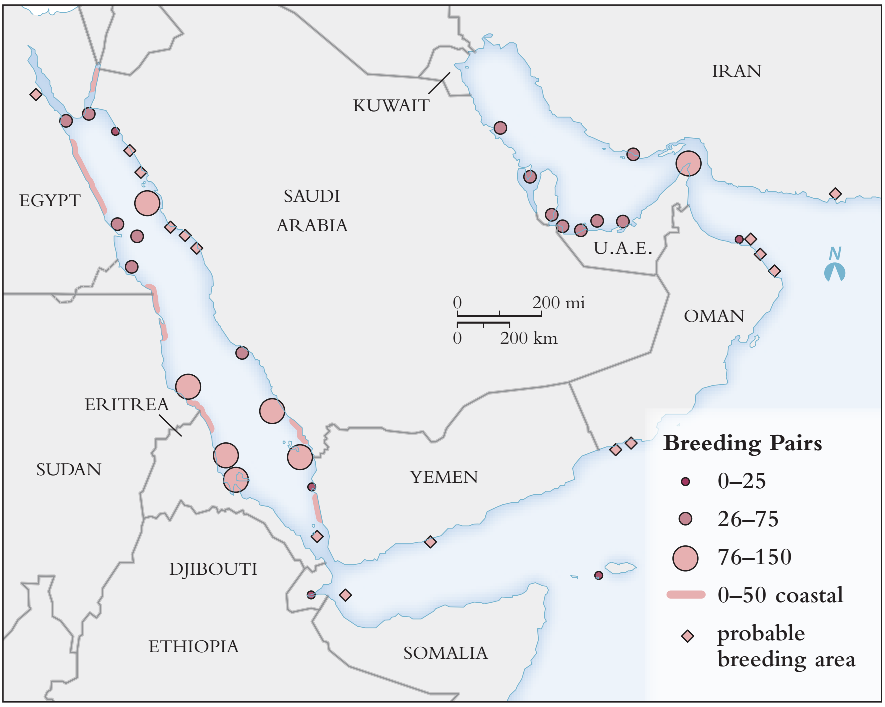
North and east of Australia, Ospreys nest on islands in the Southwest Pacific, from the coasts and lowland rivers of New Guinea to central Indonesia, including the Molucca and Lesser Sunda Islands and perhaps the Celebes and Java. We know little about these birds or their neighbors to the east and north—a somewhat forgotten population nesting on a broad arc of islands from the Bismarck Archipelago to New Caledonia, including the Solomon Islands and Vanuatu. Colleagues who recently visited New Caledonia found Ospreys surprisingly common there and quite integrated with human populations. Pairs were nesting on washed-up logs along beaches, at the tops of trees, and even on human structures including stadium lights and a large crane. Such urban-suburban nest sites remind us of the expanding population in NSW, 870 miles (1,400 km) to the west.

MIDDLE EAST

Moving back to the northern hemisphere and west across the globe, the next significant concentration of breeding Ospreys is found along coastlines surrounding the Arabian Peninsula, perhaps 1,000–1,400 pairs in all. These are desert Ospreys, a population nesting at subtropical latitudes in hot, dry, barren habitats, yet the species is surprisingly common there, with colonies of fifty to seventy pairs on a few near-shore islands. It might seem odd that Ospreys thrive there, but anyone who has slipped into these waters with a mask and snorkel will know why the birds do well. Coral reefs and shallow lagoons abound, and the waters teem with fish. The land may seem relatively lifeless, but the warm seas burst with color and life.

Three somewhat distinct nesting populations have formed in the Middle East: (1) the Red Sea shores; (2) the Arabian Sea with the Gulf of Aden; and (3) the Arabian Gulf. The Red Sea holds about two-thirds of the Middle East's Ospreys, with most nesting on small islands along the coast. There they find some protection from development and from predators, including humans. Needless to say, much of this is a lawless coast. Yemen, the Sudan, and Somalia are hardly must-see destinations for Western biologists today, so I'm not surprised to see "no surveys" or "survey incomplete" when I look at the scientific literature for some of these areas.

But overall Ospreys have been surprisingly well studied in the Middle East, at least up until recent decades. We know that a few key island colonies have been strongholds for the species, especially in Saudi Arabia—the Farasan Islands, Tiran Island, and islets off the town of Al Wajh. And we know that in the Arabian Gulf small breeding clusters can be found in Oman, Bahrain, and on western islands of the United Arab Emirates, where about 25% of the nests are on artificial platforms, demonstrating that efforts to conserve and manage the species have gained ground there. Breeding success has been robust in the few populations



Breeding range of Ospreys (*P. h. haliaetus*) in the Middle East.

studied, despite known threats: predation by a local species of mongoose, disturbance by fishermen's camps, and increasing development for tourism.

Looking ahead, however, it is difficult to feel optimistic about Ospreys in the Middle East. With some exceptions, these populations remain neglected and vulnerable, and the hodgepodge of quarreling political entities there makes regional conservation efforts a struggle, at best. And yet these Ospreys may surprise us. They have survived this long with surprisingly good numbers, and protection efforts in the Arabian Gulf point the way for others.

SOUTHERN EUROPE AND THE MEDITERRANEAN

Odysseus and his sailors plying the "wine-dark seas" of the Mediterranean would almost certainly have been familiar with Ospreys—massive nests atop rocky headlands and sea stacks, fishing birds hovering over a harbor edge, and maybe even concentrations of fall migrants on a few island strongholds. Perhaps a few Osprey nests even became navigational landmarks for these seafaring people. While we have no idea where Ospreys were found in this region 2,500 years ago, or how many might have nested there, today's population is well defined in part because so few remain. Fewer than a hundred pairs now breed in the Mediterranean basin and all are found in western portions, with Corsica the stronghold. There, thirty to forty pairs nest on seaside cliffs, most in northwestern portions of the island where parklands help protect the birds and their nesting sites.

Typical seaside nesting site for Mediterranean Ospreys: the top of a rocky promontory, here in northwestern Corsica.

Southwest of Corsica and closer to Spain are the Balearic Islands, where about twenty pairs of Ospreys retain a foothold, nesting on shoreline cliffs and, increasingly, on electrical poles. While this population was historically larger and more widespread than it is today, it has been slowly rebuilding since the 1980s. As in Corsica, however, growth in recent years seems to have hit a ceiling, with lack of nest sites and the electrocution of breeders at some nesting poles taking a toll. The good news is that conservation efforts there, led by Rafel Triay and others, have been gaining momentum. These efforts have centered on building artificial nests and protecting existing ones; on hand-raising at-risk nestlings and releasing them in promising new areas; and on modifying electrical poles to make them safer for Ospreys. Let's hope that all this will boost this struggling population.

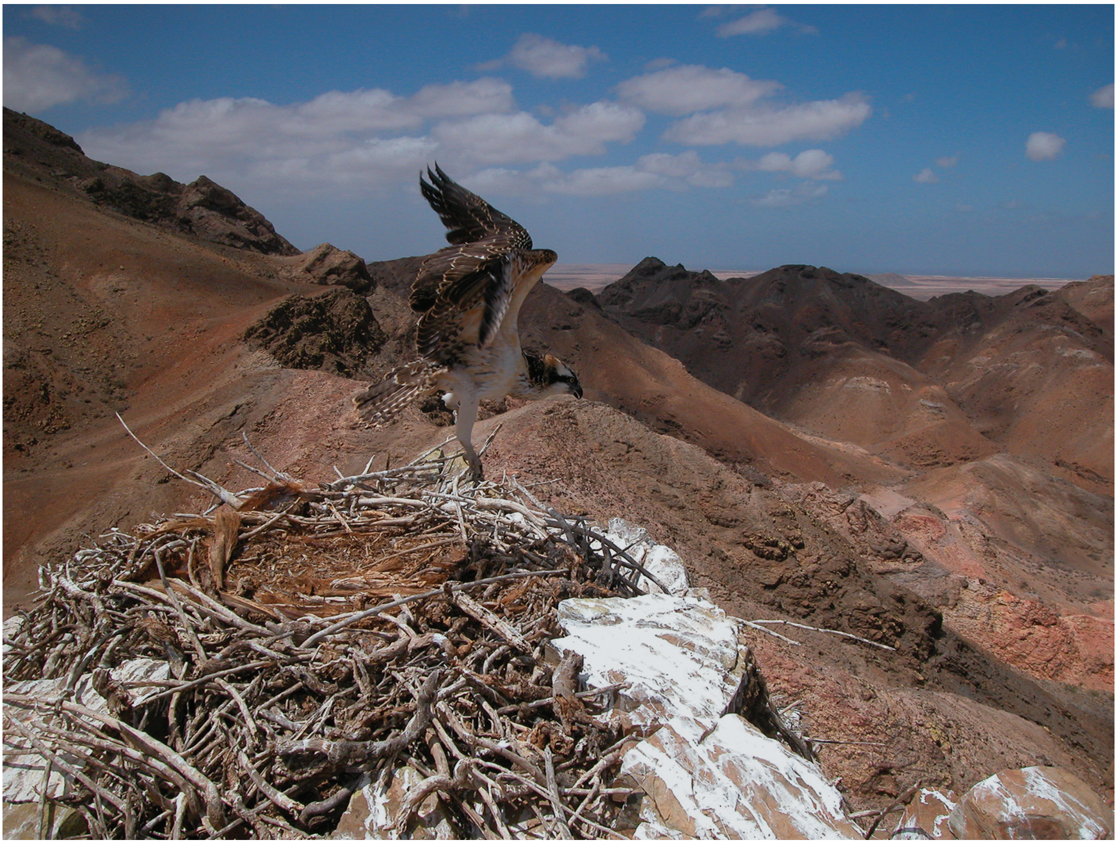
Scattered across the rest of southern Europe and the western Mediterranean are a handful of other nesting pairs, about twenty to thirty in all. Most threatened are those along the North African coast (Algeria and Morocco), where neglect and political instability put many pairs at risk. Morocco, for example, has lost 30%–40% of its breeders in the last two decades, with fewer than ten active pairs remaining in a former stronghold for the species—Parc National d'Al Hoceima. Coastal fishermen there are known to use dynamite as part of their fishing arsenal. Ospreys, one suspects, may have a tough time competing.

The picture is brighter today in southern Europe. In mainland Italy, Ospreys were slowly wiped off the map by shooting and nest robbing in the nineteenth and first half of the twentieth century, but by 1977 the species had gained protection there and researchers, led by Flavio Monti, began to release young back into the wild and protected marshes of Maremma Regional Park, Tuscany, in 2006. These efforts paid off. By 2011 the first adults had returned to breed, with two more active pairs in the area by 2016. And there is every reason to expect continued growth.

Spain initiated similar transfer projects, with even greater success, bringing in more young over a longer period of time. After a lapse of almost thirty years with no Ospreys breeding in mainland Spain, about twenty pairs now lay eggs there—in Andalusia, in the south of mainland Spain—with another ten to fifteen younger pairs starting nests in that region but not yet breeding. Corresponding efforts have brought Ospreys back into the Basque region to the north. All these birds hatched in northern Europe and were then brought south and released as fledglings (see chapter 8 for details), or they are descendants of those individuals. Breeders have settled on coastal saltwater estuaries as well as on freshwater reservoirs, with many nesting on power poles. Overall, Ospreys are adjusting well to the modern landscapes of Spain, so the species now shows excellent promise of expanding in range and numbers. With more than a thousand reservoirs in Spain, it is exciting to think how robust and widespread this population could be in fifty years, and this in a country where Ospreys were hunted to extinction just a half century ago.

ATLANTIC ISLANDS

Scattered off the northwest coast of Africa are two isolated island clusters—the Cape Verde and Canary Islands—which support small but fairly stable Osprey populations, all nonmigratory year-round residents. In many ways these birds are an extension of the Mediterranean population, with similarities obvious to anyone who has seen the two regions: nests scattered at low density, most on ocean cliffs and rock pinnacles; little protection until recently and a history of exploitation, especially by local fishermen who had few qualms about nabbing eggs or nestlings; and recent efforts at monitoring and conservation, especially by Portuguese biologists in the Cape Verde Islands. These islands, the southernmost of the eastern Atlantic archipelagos, are a fascinating mix of desert and dry coastal scrub. Among these island clusters, the Cape Verdes hold the larger number of breeding pairs with about eighty scattered across the northern windward isles. Farther



The desert landscapes of the Cape Verde Islands, off the coast of West Africa, give Ospreys little choice but to nest on the ground or on seaside cliffs. Lack of significant predators here means that ground nests are generally safe, despite their accessibility.

north in the Canary Islands (longitude 28°–29° north), fifteen to twenty pairs are known to nest at low density along rocky cliffs.

Compared to habitats on the mainland of southern Europe, a benign climate (especially the lack of extremes), tempered by surrounding ocean waters, encourages year-round residency of Ospreys on these islands. In the Cape Verdes, Ospreys are surprisingly far south—the southernmost breeding Ospreys on either side of the Atlantic—at about the same latitude as the West African country of Senegal, where so many northern European Ospreys winter. And they share similar latitudes as breeding populations in the southern Red Sea and the Arabian Gulf. Interestingly, we do not see Ospreys breeding at similar latitudes on the African continent. Competition with wintering European Ospreys may well limit such nesting, although there could also be ecological elements (perhaps snakes as nest predators) that are equally important deterrents.

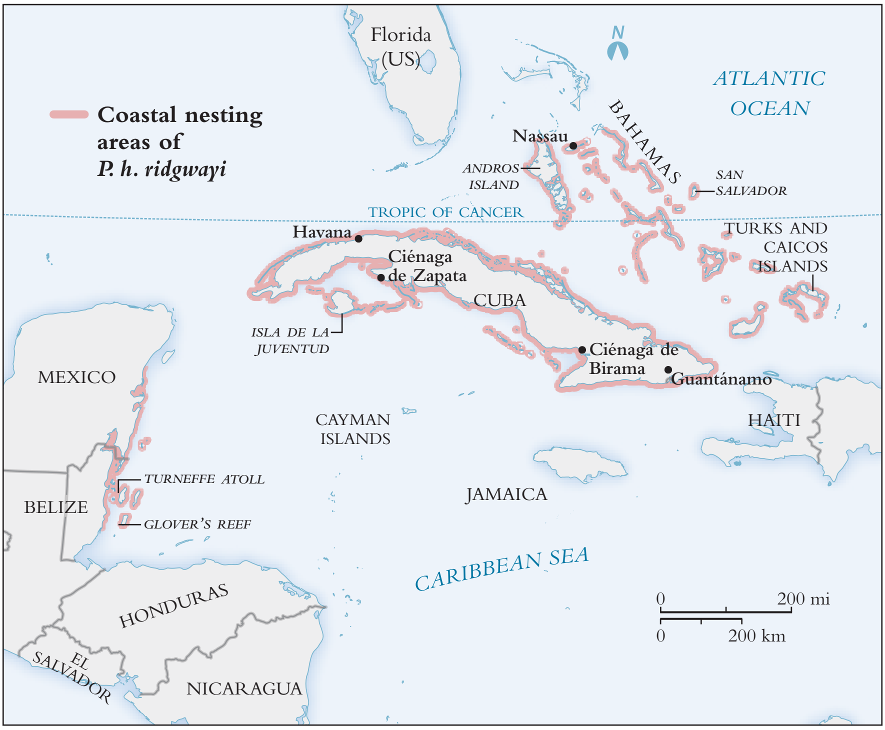
How did Ospreys find these remote islands? Some northern European Ospreys migrate at least part of the way to their West Africa wintering grounds over the eastern Atlantic Ocean, often departing Ireland or England and making landfall along the coasts of northern or western Spain (chapter 6). Over millennia, a few of these birds may have gone adrift every few years and found refuge on the Canaries or Cape Verdes, with those that survived lingering on to breed.

CARIBBEAN

Westward across the Atlantic we step into the realm of the Caribbean Osprey, *P. h. ridgwayi*. Islands that Christopher Columbus visited in the eastern Caribbean more than likely supported nesting Ospreys in his day. Today, we see a small, scattered, nonmigratory population in the Caribbean, likely severely reduced from its historical numbers. There were no viable records of Ospreys there until the last few decades, and even now only in a few areas. Like Red Sea Ospreys, this population is comprised mostly of island nesters—often low, sandy, coralline, semidesert islands—although a handful of pairs are known to nest in some of Cuba's inland wooded swamps.

Cuba is the likely stronghold for *ridgwayi* Ospreys, but the coastline of this island is extensive and remains largely unsurveyed, so we have little idea how many pairs actually breed there. Extrapolating from the scattered, low-density nature of Osprey nesting elsewhere in the Caribbean, and the extent of coastline in Cuba, there could be five hundred to a thousand pairs in all in Cuba, but until culture and politics make this island more accessible to biologists, especially to aerial surveys, we can only guess.

Better numbers are available for Belize, about 500 miles (800 km) west of Cuba, along the Yucatan Peninsula of Central America. My colleague Paul Spitzer and I have undertaken surveys in Belize in recent years, finding sixty to seventy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Breeding range of Ospreys (*P. h. ridgwayi*) in the Caribbean.

active nests, all on mangrove cays (islands) that have formed behind the fringing barrier reef that runs along the coast of this wild and magnificent little country. Most nests are high in hurricane-killed mangroves in the center of cays, with a few others lower on tiny islets where dense mangroves provide nesting support and isolation from predators. On a few offshore island groups, loose clusters of nests have sprung up—six to eight nests within a few square kilometers. But as in most of the Caribbean, Belizian Ospreys tend to nest at very low density.

Ospreys breed throughout the southern Bahamas, especially in the Turks and Caicos Islands, with nests in a variety of locations: on navigational structures, on low rocky outcrops, and in mangroves. Although there have been no thorough surveys in this region (nests there are scattered and often hard to find), an educated guess suggests there might be one hundred to two hundred pairs in all of the Bahamas. Elsewhere in the Caribbean, it is noteworthy that Ospreys are missing from places such as the Windward Islands, Jamaica, the Cayman Islands, and Hispaniola. Historical records hint that the species may once have bred in these places, but we have no accurate records.

There is one anomaly in the Caribbean Osprey story: an abrupt geographical limit to breeding. Nesting Ospreys range as far south as southern Belize, but no farther; it is a mystery why the line is drawn there. I have cruised this coast by

In the Caribbean Sea, dense mangrove trees often provide nest sites for Ospreys. Pairs here are all coastal island nesters, with many also building nests atop dead trees in the center of larger islands.

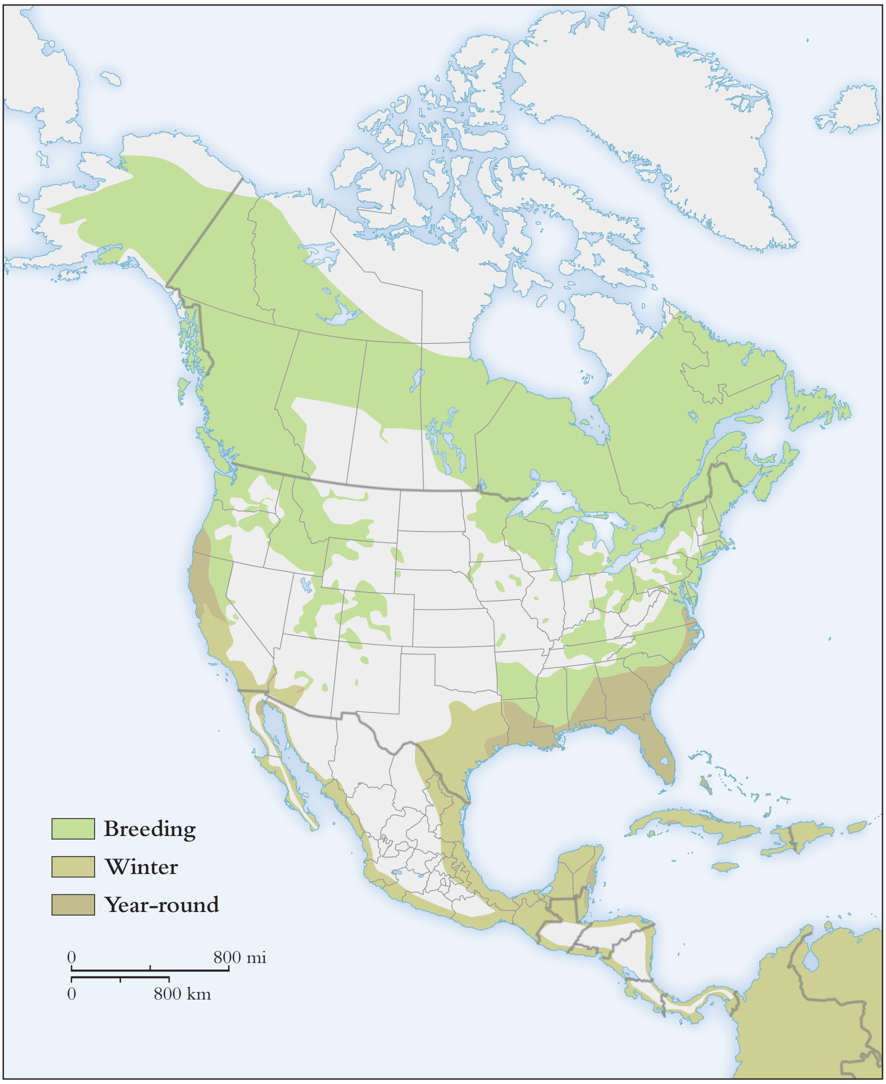
In the western Caribbean, the coast of Belize, seen here, supports a small but stable population of nesting Ospreys. The combination of coral reefs and mangrove islands powers this ecosystem. This is the southernmost region of the Americas where Osprey breed.

boat, heading south and east along the coast of Honduras after leaving Belize, and the habitat seems unchanged from that left behind—same mangroves, same coral reefs, same island possibilities for nesting, but no breeding Ospreys. Some have suggested that wintering northern *carolinensis* Ospreys increase in numbers as one moves south, potential competition for the winter-breeding *ridgwayi*, or that fish-robbing frigatebirds (*Fregata magnificens*) are more prevalent there. But neither hypothesis is borne out by the data we have. We await further studies to tell us what unknown ecological elements may be keeping *ridgwayi* Ospreys from moving farther south to nest.

NORTH AMERICA

Here we find the largest and (arguably) best-studied Osprey population on the globe, one that is widespread and expanding. Except for treeless plains and deserts in the interior of the continent, few regions are without at least an occasional nesting pair, and some areas have concentrations denser than anywhere else in the world. One sees the prominent stick nests of Ospreys from Alaskan rivers to the foggy spruce-lined coasts of Newfoundland and Labrador, from Florida mangroves to Montana reservoirs, and from the desert cliffs of northwestern Mexico to Carolina cypress swamps. All but southernmost populations are migratory, most of them flying south to winter in Mexico, Central America, and South America.

The extraordinary adaptability of the species is on display in North America, with nesting pairs occupying a broad range of habitats—both freshwater and saltwater. Freshwater nesting appears to dominate, given the great diversity of lakes, rivers, and reservoirs that support the species across inland areas, particularly in Canada but also in US states such as Florida and Oregon and even Maryland, where the upper reaches of Chesapeake Bay lose salinity. Overall, the US population numbers about 25,000–30,000 nesting pairs, with perhaps half that number in Canada. Together these account for almost two-thirds of the world's Ospreys, an extraordinary concentration—a true Osprey heartland.



Breeding range of North American Ospreys (*P. h. carolinensis*).

Current numbers and distribution in North America must be understood in relation to the past, a history that is particularly well known, at least in a handful of regions. We can summarize key aspects of this history as follows:

1. A century ago, many breeding populations tended to be concentrated, with pairs in large colonies, most nesting in trees or (on some predator-free islands) on the ground.
2. From 1950 to 1970, it was a rare population that wasn't severely impacted by chlorinated hydrocarbon insecticides, particularly DDT (more accurately, its breakdown product DDE), which killed eggs and likely some adults as well. Most populations declined very quickly during those twenty years, many by at least 50% and a few by almost 90%, barely hanging on. We cover this story in more detail in chapter 7, but what we need to know is that once DDT and similar pesticides were banned in North America, as they were in the early to mid-1970s, Ospreys recovered with surprising speed, fueled by a cleaner environment and less contaminated fish.
3. At the same time, many pairs began a shift to artificial nest sites, both those built for Ospreys (one reaction to the concern for dwindling populations was the construction of nesting platforms for the species) as well as pylons and poles that supported electrical lines, which were spreading rapidly in those years. Such artificial supports generally made safe and solid nest sites, so nests were more likely to last from year to year. Today an educated guess suggests that at least three out of every five pairs of Ospreys in North America nest on artificial sites.
4. As people became less rural and better educated about birds of prey, and as laws protecting these birds gained teeth, fewer Ospreys were shot, so the birds were more likely to nest close to human development, opening up important new breeding areas.
5. For twenty or more years after DDT was banned, growth in populations was typically exponential, with numbers often bouncing back to historical levels and beyond. Since then, we have seen population numbers level off in many areas, probably owing to a lack of nest sites, as prime sites were taken. As some regions filled up, neighboring areas were colonized that had never (or rarely) been used historically.

Given this history, we can better appreciate where US and Canadian Ospreys are found today. The core of the North American population nests along the east coast of the continent, from eastern Texas to Newfoundland, with highest densities along the Atlantic seaboard, particularly the Chesapeake Bay drainage, where the population may now exceed 9,000 pairs—almost 20% of the world population, a truly extraordinary concentration. Southern New England and nearby Long

A few lakes in south-central Florida, USA, hold the densest concentrations of nesting Ospreys in the world. The short stretch of shoreline seen here, about a mile in length, is part of Lake Istokpoga, a colony of over three hundred breeding pairs. The birds nest in cypress trees fringing the lake, with often two to three nests in each tree—Ospreys as a truly colonial species.

Island, New York, also hold significant numbers, close to 1,500 pairs, most of them saltwater nesters along the coast. Florida supports at least 5,000 pairs, with a few very large and dense colonies (more than 300 pairs) on large inland lakes in southern regions of that state. There, shallow productive waters make fish readily available and flat-topped, wide-branched cypress (*Taxodium* species) trees along lake edges provide ideal nest sites, a single tree often holding multiple nests.

Ospreys range west across forested Canada and the Great Lakes region of the United States to Alaska, where pairs breed up to treeline south of the Brooks Range. Canada supports a few nests as far north as longitude 59° along the coast of Labrador and at least one extraordinarily as far north as longitude 68° in the province of Nunavut—arctic Ospreys in a treeless tundra environment, dependent on human structures for nesting. We have to wonder about these birds, their origins, and how they found their way to such remote locations.

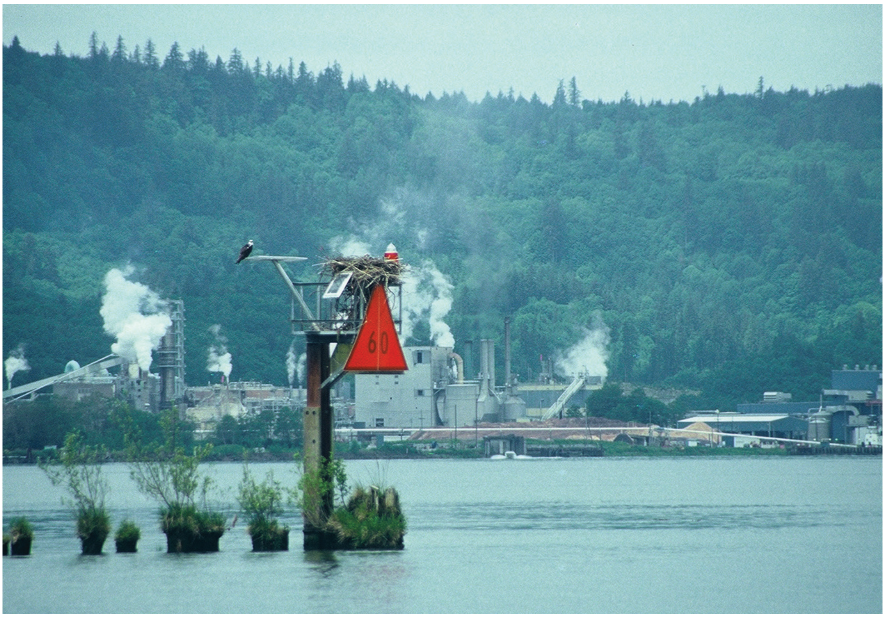
Density is generally low in Canada's boreal forests—a vast region with few people—so we have little idea how many Ospreys actually breed there. Many of these Canadian Ospreys tend to be true wilderness birds, breeding on remote lakes and rivers with nests atop large trees, although increasing reports tell of nests on power poles near human settlements. On two separate trips I canoed for hundreds of miles through remote forested regions of Canada's Northwest Territories and never saw a single Osprey. Bald Eagles were numerous, however, and seemed to rule there—perhaps one reason Ospreys were missing. Sweden holds at least four thousand pairs of Ospreys in forests that are ecologically similar but only about one-tenth the size of Canada's, so there may be potential for significant numbers in North America's boreal forests.

The species appears much more numerous in Canada south of the boreal forest, into the Great Lakes drainage. Regions such as Kawartha Lakes and Georgian Bay, summer cottage country, have well-monitored Osprey nesting populations of about sixty pairs each, many on artificial platforms. And breeding bird atlases for Ontario and Quebec show far more Ospreys in the mixed and broadleaf forests of the southern lake plains and the St. Lawrence River valley than in northern forests.

Just south of the Great Lakes, in the Finger Lakes region of western New York State, a small but fast-growing population of eighty to a hundred pairs has sprung up in the past two decades, reminding us how effectively North American Ospreys are pioneering new habitats. These Finger Lakes pairs nest almost entirely on artificial sites—power pylons, lighting arrays, and platforms built to lure Ospreys. In addition, a number of different introduced fish are helping to power these birds through parts of the season when native fish are scarce.

And this is not an isolated example. Reintroduction (hacking) programs have helped to seed many inland areas of the United States with nesting Ospreys, with reservoirs proving to be a key habitat for building populations. It is a rare river or reservoir across the Gulf Coast states that doesn't harbor at least a few Osprey nests today, and even midwestern states now have small but growing breeding populations. By 2015, nesting Ospreys were absent from just two or three US states, while twenty to thirty years ago that number was at least twelve to fifteen.

In western reaches of North America, mountain lakes and rivers hold scattered pairs, but concentrations tend to be at lower elevations, particularly around reservoirs. In Montana, for example, reservoirs at Flathead Lake and along the upper reaches of the Missouri River support 150–200 nests, in total, with many on platforms. Fish caught in the warm shallow reservoir waters are powering these birds and attracting increasing numbers of them. Impressive concentrations are also found in the large river basins of the far west, such as the Columbia/Willamette drainage of western Oregon. These populations have seen extraordinary growth in recent decades, with Willamette River Ospreys now over 250 pairs strong, up from fewer than 20 in the late 1970s. Here again many pairs are nesting on power poles, in this case large steel pylons supporting electrical lines, helping to drive this very fast growth in numbers. Likewise, along the coast of California, San Francisco Bay has seen new pairs attracted by artificial nesting sites, with some birds even moving into industrial sections of that coastline.



Providing stable overwater nest sites, navigational structures have played a key role in the growth of Osprey populations in the United States. Here we see such a nest in the Lower Columbia River, Oregon, USA. Note the industrial landscape in the background; Ospreys adapt readily to such disturbed sites.

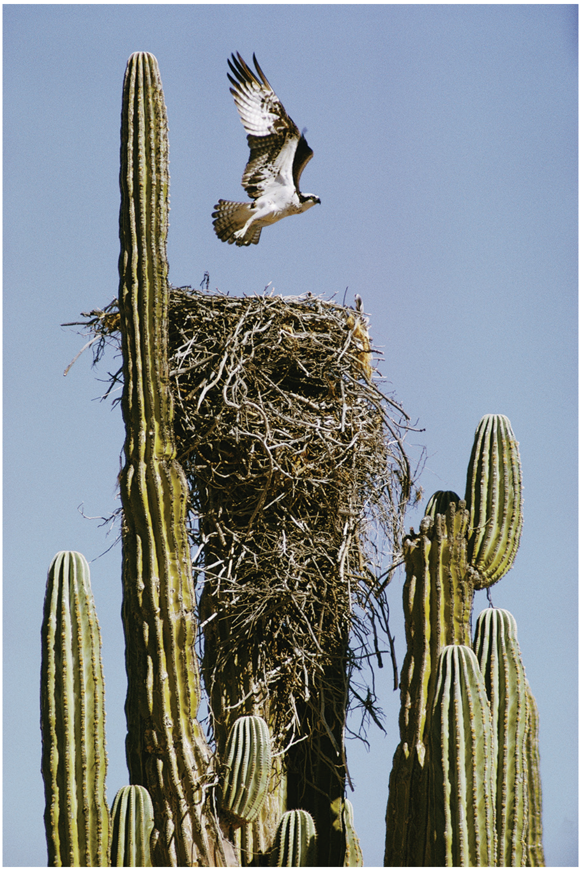
At the other end of the spectrum, in the deserts of eastern California, a small population is now established at fishless, hypersaline Mono Lake, with the birds nesting on strange calcareous rock towers and flying to nearby lakes and rivers to forage. And in the mountains of Arizona, a state where Ospreys were historically rare or missing until recently, thirty to forty pairs now nest along rivers and lakes, with the population growing and even a few pairs at lower elevations moving out onto reservoirs and into the Sonoran Desert along rivers. Here again we are reminded that Ospreys are nothing if not adaptable.

NORTHWESTERN MEXICO

Often considered to be geographically part of North America, Mexico is home to a significant breeding population of Ospreys in its northwestern states, and to thousands of wintering individuals from the United States and Canada farther south and east. Interestingly, there is little overlap between the two groups, suggesting most migrants move through nesting areas, perhaps to avoid competition. Mexican breeders are concentrated along the coastline of the Gulf of California, which separates the Baja Peninsula from mainland Mexico, and along Baja's Pacific coast. Much of what we know about these birds we owe to persistent efforts by the US Fish and Wildlife Service's C. J. (Chuck) Henny and his colleagues, who flew aerial surveys there in 1977, 1993, and 2006. Their 2006 tally found 1,343 nesting pairs in the region, an 81% increase since 1977 but only a 3% increase since the 1993 surveys. It appears that this population may have hit a ceiling, probably owing to lack of nest sites.

These Mexican Ospreys are essentially desert birds. Numerically, the most important nesting substrates there are cliffs along the sea, with 30%–50% of the pairs using such sites, depending on the year. Sometimes the cliff sites consist of large rock pinnacles or stacks on which the Ospreys build their nests. Lacking trees as nesting sites, many Ospreys take advantage of large columnar cacti (about one-third of the pairs use such sites, with the giant cardoon cactus [*Pachycereus pringlei*] predominating), especially on flat terrain. And on the west coast of the Baja Peninsula, a few loose colonies sprang up historically as ground nesters around large saltwater lagoons, although predators and disturbance appear to have driven many of these birds onto power poles in neighboring towns, with almost two hundred pairs now in these locations. It is not clear to what extent these poles have been modified to accommodate Osprey nests, so risk of electrocution may run high with these birds.

The heart of this Mexican population lies in the Gulf of California, both the islands in the gulf and the coastlines that border it. On the western (Baja) side of the gulf, Henny's 2006 survey found about 250 Osprey pairs, with islands holding about the same number. On the eastern side, along the coast of Sonora and Sinaloa, numbers decreased by about 100 pairs in Sonora during the years of the



In northwestern Mexico (Sonora), many Ospreys nest in cacti, sometimes building up huge nests like this one.

survey, while farther south into Sinaloa there was an increase of about that number over the same period (to a total of 285 pairs), suggesting a southern shift of breeders. Although some of this area is protected, much of it is vulnerable to development, so it remains to be seen how these Ospreys will fare in the decades ahead.

EUROPE

If you could ride a satellite over Europe on a cloudless night, somehow magically dousing all of civilization's lights and instead having each Osprey nest shine bright, the view out your window would be revealing. Where the human landscape had previously lit up, your night map would be almost blank. Instead, areas farthest from people would gleam, especially the vast tracts of forest that still remain in northern Europe. In the heavily forested countries of Norway, Sweden, Finland, and western Russia we find the heartland of the European Osprey. Northern Scotland would glimmer, and parts of Germany would glow, especially in the north. And there would be pinpricks of light in England and central France, as well as in a few areas of Eastern Europe and the Mediterranean. But the map you'd take home in your head, the indelible image, would be of a swath of light across the great boreal forests of Scandinavia, Finland, and Russia.

Two hundred and fifty years ago, if you could have commandeered that same satellite and worked the same lighting magic, you likely would have seen a very different picture, one fuller and less lopsided. Nests would have been more broadly

Europe's northern forests hold most of the Ospreys nesting on that continent. Many of these birds have benefitted from human efforts to build nest platforms in trees, as in this Finnish forest.

Risto Mattila 2016 ©

distributed, especially across Eastern Europe and parts of the south, and even throughout the Mediterranean. Why this change, why the patchy distribution we see today?

Answers lie largely in a study of human cultures. Much of this I cover in more detail in chapter 7 but, in a nutshell, guns and traps brought European Ospreys down. People in countries hungry for protein saw Ospreys as competitors for dwindling fish resources. On top of this was a far less hungry class of wealthy landowners fearful of losing the trout and other fish they pursued for sport. Their hired gamekeepers were determined killers of Ospreys, especially as firearms increased in power and accuracy in the nineteenth and twentieth centuries. And overarching all this were long-held cultural attitudes that saw birds of prey as vermin. Only in the remote forests of northern Europe did Ospreys find refuge from people trying to hunt them down.

Not until the mid-twentieth century did this begin to change, and the transformation in human attitudes since then has been astonishingly quick. In the past fifty years, for example, over one million tourist-naturalists have visited a single Osprey nest in Loch Garten, Scotland—something that would have been unthinkable a century earlier. And interest in other parts of Europe, while not quite this intense, is growing fast. Along with this interest, not surprisingly, comes protection.

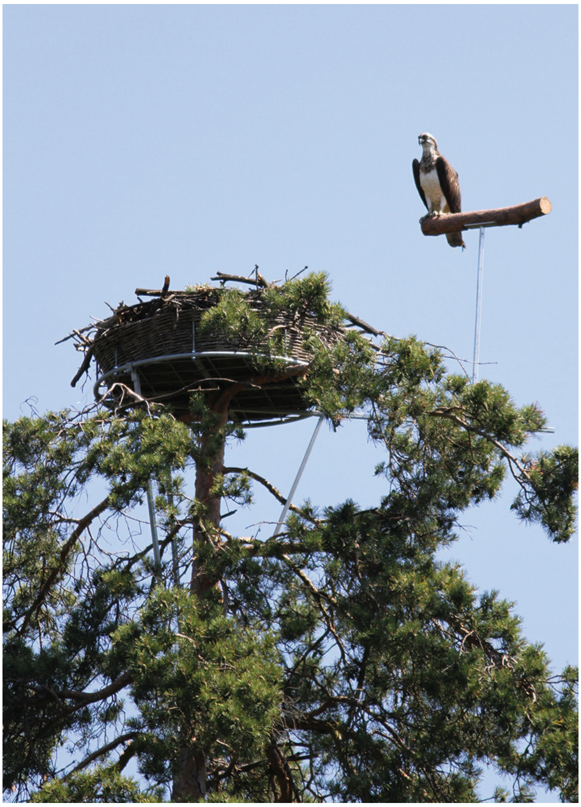
Contrasts with American Osprey populations are illuminating. For one thing, European Ospreys are almost entirely freshwater birds, dependent on lakes, ponds, and rivers, while about half of North American breeders rely on saltwater fish. And there are big differences in numbers. Compared to their European counterparts today, American Ospreys are three to four times as numerous and far more concentrated in the areas where they nest. As we have seen, in Chesapeake Bay alone, an estuary about the size of Denmark along the US mid-Atlantic coast, over nine thousand pairs of Ospreys nest each year, almost as many as in all of Europe (Denmark has three to five pairs). And Europe lacks the concentrated nesting colonies that have defined American Ospreys for generations. On both coasts of the Americas, small estuaries—just a handful of square kilometers in area—often hold fifty to a hundred nesting pairs, and on a few small Florida lakes we now find three times that many, local numbers that Europe has never seen, even historically.

There are good ecological reasons driving these differences—food, nest sites, and predators—but history plays a role as well. Ospreys were never persecuted by people in the Americas to the degree they were in Europe. And there were always more fish there, more wild land, and less of a landed class of people trying to protect fisheries and harass predators. As a result, Ospreys were able to slip through the cracks even though other species of American wildlife fared less well. Finally, while contaminants took a big toll on American Ospreys, reducing overall numbers by at least 50%, European Ospreys appear to have better survived this threat (chapter 7). Overall it is probably fair to say that European Ospreys have had a much tougher time navigating the world humans have created, although there are now reasons for optimism as we see many European populations starting to recolonize parts of their historic range.

Here we provide a glimpse of the history and current status of Ospreys in Europe, circa 2016. No part of the world has a more exciting Osprey story to tell, or as many people involved in the telling.

The Northern Forests: Scandinavia, Finland, Russia

This is the stronghold of Ospreys in Europe, with Sweden and Russia together supporting more than two-thirds of the current continental population. In Sweden alone, estimates suggest that more than four thousand pairs build nests each year, most in the southern third of that forested country and many clustered around lakes. Likewise in Finland, the well-monitored population of about 1,200–1,300 pairs is centered in the forested lake country of southern and central portions of that country, with fewer pairs north of that and even a handful up into arctic Lapland, where nesting trees eke out an existence protected in small river valleys. Russia is the anomaly here. Estimates suggest 2,000–4,000 pairs for western Russia but we really have no clear idea of Osprey numbers there. The region is



The recovery of the German Osprey population over the past several decades has been driven in large part by the construction of artificial nests, such as this one in Bavaria. Note how the top has been cut out of this tree and a nesting basket secured to its upper branches. Even a perch has been added to make sure the birds feel at home.

too large and resources too few; in the Russian economy today wildlife monitoring remains a low priority.

If you could drop into one of these northern European forests and begin to wander, you would be far more likely to see orchids than Ospreys. That was my experience in the summer of 2016, touring forests of central Finland with my local host and colleague, Pertti Saurola. We drove back roads to areas where known Osprey nests were located, but even then we often walked half an hour or more after parking our truck, through fragrant spruce and pine forest and orchid-rich bogs, before we heard the high-pitched calls of nesting Ospreys alarmed by our appearance. The average distance between nests in Finland is 10–15 miles (16–24 km), with similar figures for most of Scandinavia, except for a few lakes in southern Sweden where nests are loosely clustered.

Stability has been central to these populations, at least since the pesticides era of the 1950s through the 1970s. Population data for that period are few, so it is unclear how much these birds were impacted by contaminants (the few eggs sampled did show high levels of DDT), but since more effective population monitoring started in the 1970s and 1980s nesting numbers have changed little, except for a slow and steady increase in Finland, driven largely by the provision of artificial nest sites. Over half of Finland's Ospreys now occupy artificial sites, most built in the tops of old pines by a dedicated crew of volunteers.

Scotland and England: Making Britain Great Again, with Ospreys

Anyone looking for an uplifting story in the world of Osprey conservation would be hard put to find a better one than the United Kingdom has to tell. Although Osprey numbers are still low there (around 250 pairs), at least by US or Scandinavian standards, the resurgence of the species over the past sixty to seventy years gives hope to Osprey enthusiasts everywhere. Confined to Scotland by the early twentieth century, and reduced to a handful of nesting pairs by the guns and traps of gamekeepers and by the greed of overzealous egg collectors, UK Ospreys were hanging on by a thread when popular support began to swing in their direction, starting in the late 1950s. In large part this support was triggered by the appearance of a nesting pair at Loch Garten, Scotland, which galvanized conservation efforts. Twenty-five years later a million people had made the trek to see this nest, thanks to an Osprey Center that had been built around it, and at least thirty other pairs were breeding in nearby areas of Scotland.

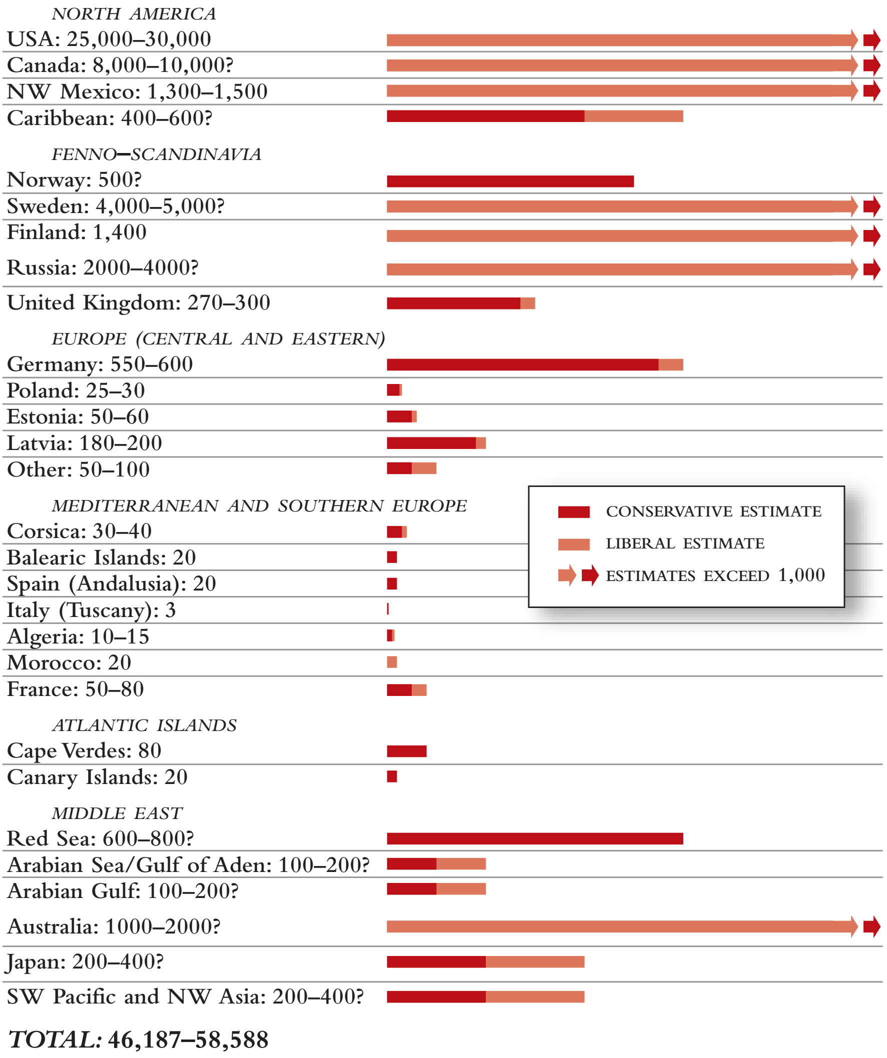
In 2016 Ospreys were starting to reach out into their former range in Great Britain. While the bulk of the UK population still nests in the Scottish Highlands, their foraging focused on lakes and rivers there, a few pairs have moved south to the English border regions, taking up residence in the Lake District. And in an effort to jump-start nesting in the United Kingdom, researchers relocated fledglings from Scotland to the Midlands of England starting in 2000, where almost a dozen pairs, part of that group or descended from those transfers, now nest on and around the reservoirs of Rutland Water. From there the birds have dispersed on their own to lakes in Wales, further tribute to the reach of this operation.

France and Germany: Ospreys in the Heartland of Europe

If there is any doubt that Ospreys are making a comeback in Europe, one has only to look at France and Germany, whose Osprey populations have turned out to be surprisingly linked. Historically, the few records available suggest our bird was fairly numerous and widespread in both countries up to the mid-nineteenth century, with persecution taking an increasing toll over the next one hundred years. By 1950–70, Ospreys had largely disappeared from France and were down to a remnant population (fifty to one hundred pairs) in Germany, perhaps held down as well by pesticides in their food webs.

As in so much of the Western world, the 1970s marked an environmental turning point in both France and Germany: curbing the flow of contaminants into habitats and boosting protection for wildlife. Ospreys rebounded first in Germany, with numbers of nesting pairs doubling by the late 1980s, and doubling again in the following decade. Much of this growth was focused in lake districts in northeastern portions of the country. Here again, as in so much of Europe and the United States, artificial nest sites were driving this surge. Well-coordinated efforts to modify trees and power pylons lured Ospreys into suitable habitats and kept them there and productive, generating new recruits for the population year after year. Brandenburg was the center of this resurgence in Germany because it

Typical Osprey nesting habitat in central Europe. Here in Bavaria (Germany), fishponds, now part of a wetland nature reserve, have been taken over by natural succession. Ospreys nest on the edge of this pond and forage here and in nearby lakes.



Estimated population size (number of active pairs) for Ospreys in different parts of the world, in 2015. Regions with the best estimates are those with the most active Osprey research programs.

retained large forests with suitable nesting trees, and had foresters who helped protect those, as did parts of Mecklenburg. But electric companies held the key to the growth of German Osprey populations, cooperating with biologists to help modify hundreds of power line pylons from the 1980s on. Today at least 80% of Germany's five hundred to six hundred pairs of Ospreys nest on pylons, many of which have been set up to accommodate nests.

Such efforts not only stabilized existing populations but helped to expand the range of Ospreys in Germany, starting in the early 1990s. The species has now colonized northwestern portions of the country (Lower Saxony) as well as Bavaria in the south. Looking ahead, it seems fair to say that Germany will remain the Osprey center of central Europe, with the potential for perhaps double or triple the current number of breeders if efforts continue to accommodate the birds with new nest sites.

Daniel Schmidt-Rothmund

BRINGING AN OSPREY REVIVAL TO GERMANY

A German by birth, Daniel Schmitt has been the spark plug for Osprey research and conservation in Germany since the 1990s. His interest in the species was kindled during college when he spent a year at St. Andrews University in Scotland. There he met Scotland's legendary Osprey guru, Roy Dennis, who encouraged him to look more closely at German Ospreys, at that point (1998–99) largely unstudied. Daniel found his target and never looked back.

Daniel's work has focused on nesting populations in northeastern Germany, the Osprey heartland of that country, as well as in Bavaria (southeastern Germany). He spearheaded the Osprey color-banding program in Germany, one of the most comprehensive in Europe, a program that has helped shed light on the dynamics of Osprey populations in that region. Juveniles color-marked in German nests, for example, turned up several years later as breeders in France, part of the pioneering new cohort of Ospreys that have been colonizing that country. Without those bands, the source of those new breeders would have remained a mystery.

In addition, Daniel has led the charge on construction of artificial nests in Germany, a key aspect of the very rapid population recovery seen there since the 1980s. Daniel himself can take credit for building more than two hundred artificial nests, which he continues to maintain and oversee, and he seems to have mastered the ability to reach nests on the towering pylons holding electrical lines. With up to 230,000 volts running through those wires, checking Osprey nests on those giant structures is clearly not for the faint of heart.

Daniel has also been active in Osprey translocation projects in Europe, generously providing over one hundred German fledglings to restoration efforts in southern Spain. Without that influx of young Ospreys it is safe to say that the now rapidly growing nucleus of breeders in Spanish Andalusia would be a small fraction of what it is today.

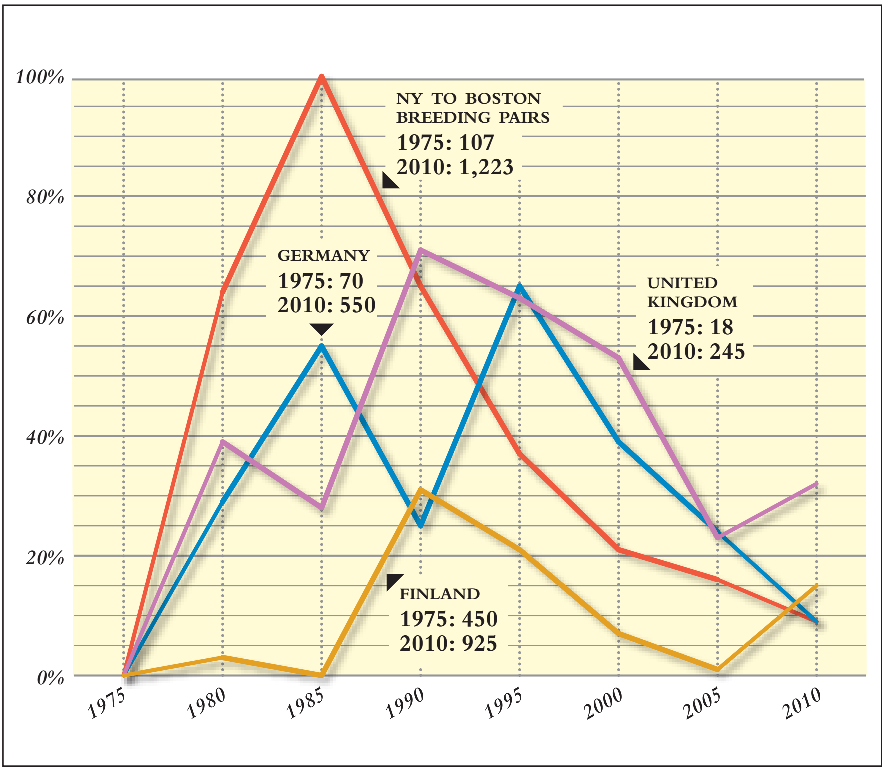
Published results help drive new research and keep people informed about the value of conservation efforts. Daniel has never been one to hide his candle under a basket. He has led the way with Osprey publications in Europe and his writings cover

France has benefitted from this expansion of German Ospreys, even though their respective nesting centers are hundreds of kilometers apart. German Ospreys migrate through France, with traditional stopovers at ponds and lakes in north-central France, in the Loire Valley and nearby Sologne—the region where a few remnant French pairs had survived. Perhaps not surprisingly, a handful of German Ospreys, younger birds and mostly females, settled at the French nests and paired with males (much to the delight of my French colleagues, who were quick to point out that life in the Loire Valley has advantages not to be found in Germany). Leg bands were the key to identifying these German birds, so here we see how persistent banding of fledglings helps shed light on the dynamics of Osprey populations.

a wide range of topics on the history and population dynamics of Ospreys in Germany and neighboring countries. Recognition of this work includes an Erwin Stresemann Research Grant from the Deutsche Ornithologen-Gesellschaft (German Ornithologists' Society) in 2003.

Daniel continues his work on Ospreys as a contractor and advisor for a wide variety of organizations: government authorities, forestry commissions, foundations, nongovernmental organizations, landowners, and the US military (Garrison Bavaria). All this is testimony to the depth of Daniel's interest in German Ospreys, and to his unflagging devotion to the species. Few in Europe have given more time and energy to Ospreys, to the great benefit of the species.

Buoyed by the influx of German Ospreys, but still largely dependent on local reproduction, French Ospreys began a slow recovery starting in the 1980s. Rolf Wahl discovered many of these early nests and documented the recovery, showing that extensive oak and pine forests near the city of Orleans held the core of this population, with most nests atop large Scots pines deep in forest interiors. Some trees were modified to accommodate nests, and some pairs moved onto power pylons in outlying areas, but overall this has been a less intensively managed population than those of the United Kingdom, Finland, or Germany. Perhaps as a result, growth has been modest but today at least fifty to sixty active nests are known in France, with perhaps twenty to thirty others still undiscovered.



Rates of growth of four key Osprey nesting populations in different parts of the world. Data show percentage increases over five-year periods to demonstrate how quickly each population was growing. Note that all shown here were increasing in size, with the highest growth rates seen in the years 1980–95.

Eastern and Southeastern Europe: Ospreys on the Edges

Moving south and east from France and Germany, the Osprey picture becomes bleaker. The late-twentieth-century resurgence in numbers seen in western and northern Europe never materialized to the east and south, a victim of sagging economies, lack of conservation interest and leadership, and overall resistance to change. That said, a few bright spots remain in the Baltic States of Estonia and Latvia, as well as adjacent Belarus, with a combined Osprey population almost equal to that of Germany's. Extensive forests and productive lakes help to nurture those birds. And in Switzerland, currently lacking nesting Ospreys, there are efforts under way to reintroduce the species by releasing fledglings from northern populations.

Elsewhere the numbers are much less encouraging—perhaps 100–150 total in all of the other countries of eastern and southeastern Europe combined. Poland, once a stronghold for the species, has seen its Ospreys dwindle to just a few dozen pairs in recent decades, likely jeopardized by the large and growing fish-farm industry in that country, and lack of wildlife protection. In Greece and Turkey, Ospreys appear to have been wiped out. One struggles for optimism in the face of these discouraging numbers, but if Western Europe rebounds to near historical Osprey numbers in the next century, perhaps there's a chance for a spillover of birds and interest into these neglected areas of the Osprey map.

Knowing where Ospreys live and how their numbers have changed over the last thirty to fifty years, we turn next to how they live, in particular how they go about finding and catching the food that keeps them going. For almost two months of the year an Osprey pair that succeeds in hatching eggs is faced with significant demands—doubling or tripling the amount of fish that gets lugged back to the nest each day, and then deciding how much to eat themselves and how much to provide to hungry nestlings. Some pairs struggle to meet these demands, but those that do are the ones that leave the most viable offspring to future generations, which in the Osprey's world is what it's all about.

FOUR

Finding Food

A few years ago, an adult male Osprey drowned in a fishpond in central France, tangled in nets from which it couldn't escape. The carcass was brought to Rolf Wahl, who had been studying French Ospreys for decades. A curious and determined naturalist, Rolf pulled out his dissecting tools and went to work on this bird, his first chance to look at an Osprey from the inside out.

Among Rolf's many discoveries was that Ospreys have an extraordinarily long digestive tract. To be more specific, their small intestine, which accomplishes most of a bird's digestion, measured eight to nine feet (265–85 cm) long when uncoiled to its full length! While other birds of prey are also known to have long intestines, the Osprey's was considerably more than might be expected for a bird its size. It seems that evolution has fitted Ospreys with a gut well designed to wring every last nutrient and calorie out of the food passing through it.

This chapter considers how Ospreys go about filling that gut: from the initial decision of where they choose to forage to how they find and catch their prey to what goes into that gut and what gets dropped along the way to how they share food within a family. Ospreys are superbly well adapted to find fish in varied waters, weather, and habitats. Consider a year in the life of an Osprey—the shifts in where they forage, in what they catch, and in how they go about securing the live fish that make up their diet. In the course of a two-week migration, for example, an Osprey that leaves its nest in a Scottish pine forest might find itself searching for fish along the rocky margins of a Mediterranean beach; in the choppy waters of a wind-blown Spanish reservoir; in a shallow, muddy Sahel lake; and in the dark, tannic waters of a mangrove estuary along the coast of Senegal. Failing to find fish, a bird must move on, with survival increasingly at risk with each passing day. No aspect of an Osprey's life is more vital.

As we've seen, Ospreys are "fish hawks," and many people still refer to them that way. It's an apt name. Study after study has shown us that an Osprey's diet is almost exclusively (99%) live fish. Scattered through the literature are stories of

Ospreys eating other things, but these are the rare exceptions; day in and day out, fish are what nourish this bird. That said, the exceptions are interesting, even bizarre. A handful of individuals in one Red Sea colony learned to take large snails (conchs—*Lambis* species) aloft in their claws and drop them on rocks, breaking the shell and exposing the meat within. And there is at least one Osprey nest near a US lake in western New York State where researchers continually find water snakes (*Nerodia sipedon*), suggesting that a few foraging males may specialize in those smelly and aggressive reptiles. But it seems hard to imagine a brood of young Ospreys surviving largely on snakes (or conchs, for that matter), to say nothing of how they deal with writhing serpents in the nest. Lastly, there are occasional reports of Ospreys feeding on carcasses, roadkill for example. These birds tend to be migrants that return early in the season, when the weather is cold and fish scarce. In other words, it takes a hungry Osprey, probably a starving one, to settle on a dead carcass.

Having to eat just fish (piscivory) might seem a serious restriction. Other species of hawks take a much more diverse diet—birds, mammals, insects, frogs, and reptiles. But piscivory is not that narrow a niche when you consider that there are at least 30,000 species of fish on the planet and that about two-thirds of the globe is covered in water. Of course much of this water is open ocean, far from land and inaccessible to Ospreys. And many of those fish are deep-water species, well out of reach of these birds. But that still leaves a lot of water, a lot of coastline, and a lot of lakes and rivers—in short, a lot of fish. And the Osprey's broad range reflects this. Among birds of prey, only the Peregrine Falcon, with its catholic taste for the planet's many birds, is spread as wide.

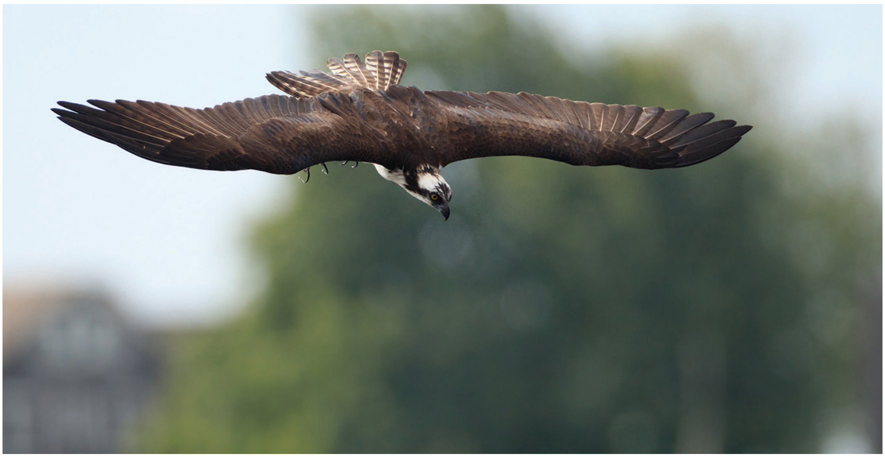
An adult male Osprey starts to look for fish. Soaring, mixed with occasional hovering, characterizes this early stage of the hunt. Massachusetts, USA.

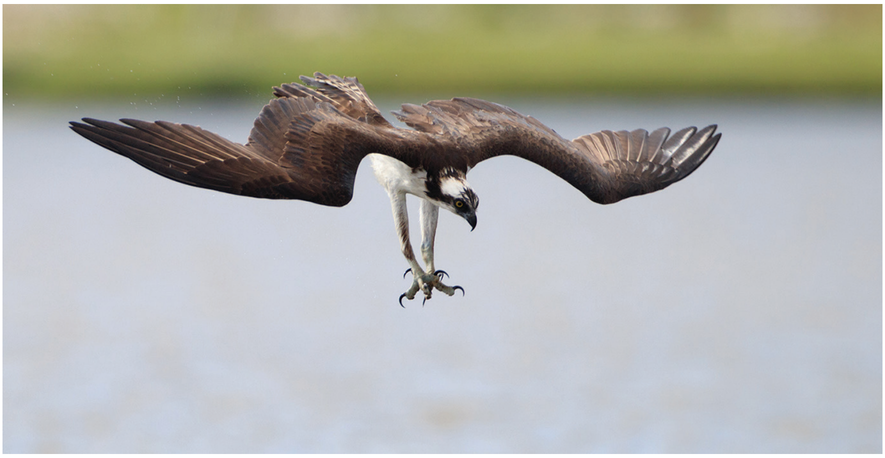
Ospreys dive for their fish, feet first. But they can dive only about half a meter deep, so it is surface-schooling fish and those in shallows that are most available to them. Some of those fish live in shallow water all the time but others come there, or to the surface of deeper waters, to feed and lay eggs, and are then vulnerable to Ospreys. Not surprisingly, Ospreys are found at their highest densities where shallow waters abound—areas such as Chesapeake Bay and Long Island Sound on the US East Coast, Montana reservoirs and the Gulf of California in western North America, coral reef lagoons in the Red Sea and off eastern Australia, and mangrove estuaries along the coasts of West Africa and Brazil, to name just a few.

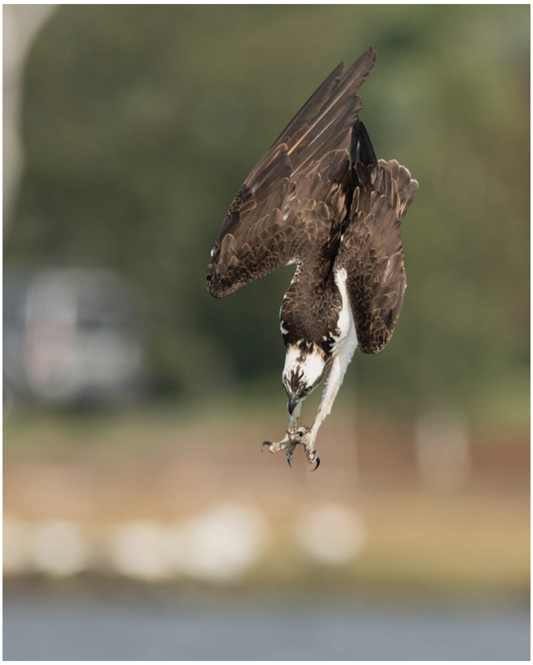
There is another key restriction that Ospreys face—for five to six months of the year most adults are tied to a nest. Any fish they catch must be within "reasonable" commuting distance of that site. This means that, overall, the birds cannot expend more energy in finding their fish than they gain from eating them, and in fact the equation needs to tip fairly heavily toward gain. What little we know about the foraging ranges of nesting Ospreys, mostly data from males wearing satellite transmitters, suggests that 15–20 miles (24–32 km) is the maximum distance they are likely to fly on any foraging trip. And most find their fish much closer to the nest, within 5–10 miles (8–16 km).

Diet and foraging ecology are some of the best-studied aspects of Osprey life history, with studies spanning the globe from Australia to the Red Sea and from Scotland to British Columbia. This is because Ospreys tend to be conspicuous hunters and feeders. They hunt over open water, unlike a forest raptor darting through thick leaves after elusive birds. And, at least during the breeding season, they generally eat their fish at their nest, or nearby—pretty much always out in the open. Set up a telescope and settle in to watch an active Osprey nest, making sure you are far enough away so as not to disturb the birds. You'll quickly see how easy it is to keep tabs on what fish are brought in and how those fish are divided up and eaten by different members of an Osprey family. And I suspect you'll find yourself taken in by the pleasures of being out in Osprey country and a watcher at the nest.

In areas where nests have been most closely studied—Rutland Water in the United Kingdom, Loch Garten in Scotland, and nests in the United States where webcams have been installed—it has been possible to follow almost every feeding at a nest from dawn to dusk, sometimes over multiple years. Many of those data await detailed analysis, especially those from webcams. But a general overview of the Osprey diet is now available from dozens of closely watched nests. We are helped in this overview by the fact that Ospreys are often messy eaters. They discard portions of the fish they cannot swallow, or don't want to—large bones and tails, hunks of scales and skin, intestines, and gill covers, known as opercula. These remains, picked up by researchers under feeding perches or at nests, become key

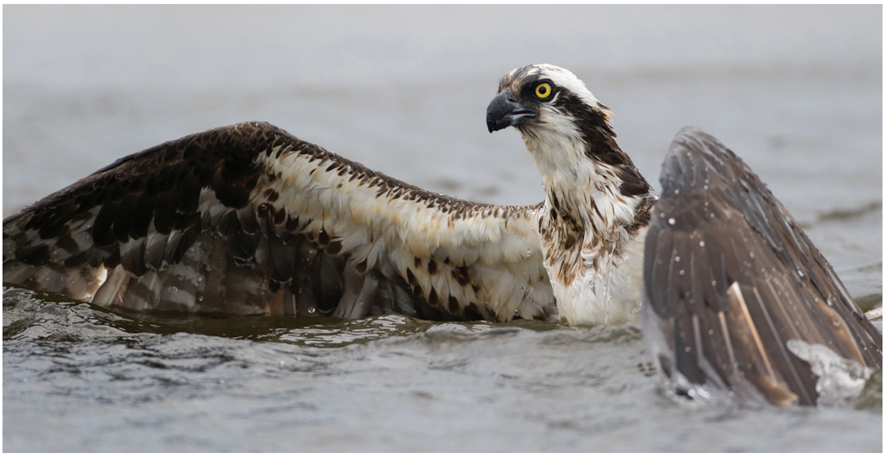


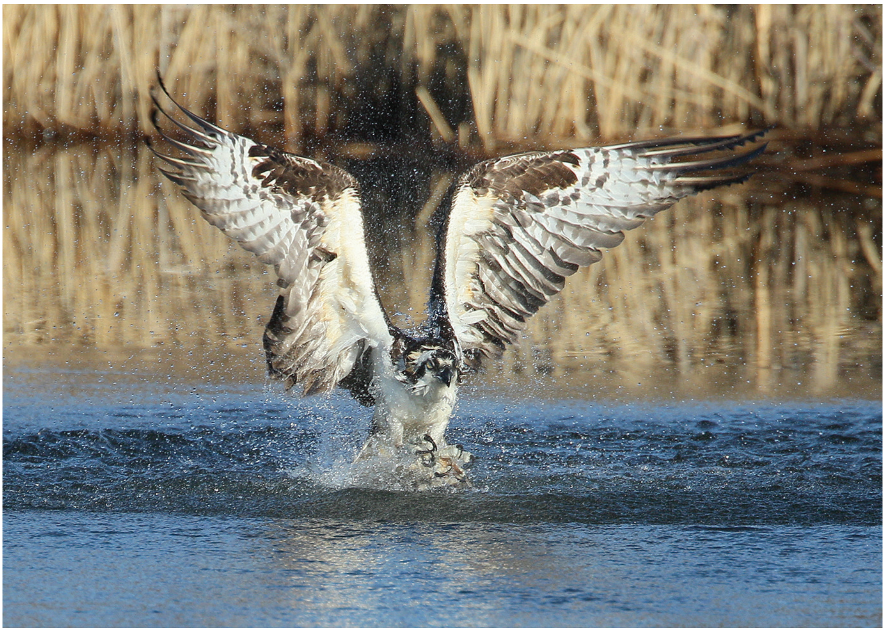


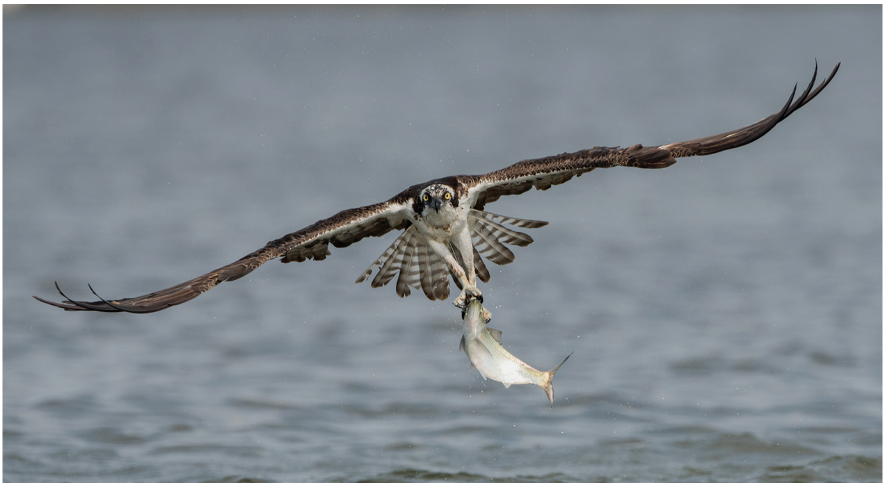


Top: An Osprey committing to a plunge, the first stage in its dive on a fish. *Middle:* A few seconds later, its feet start to swing forward. *Bottom:* The final stage of the dive, just before the bird hits the water. Note the eyes lined up behind the talons, helping the bird zero in on its prey, and the right wing slightly extended to readjust the track of its plunge. Connecticut, USA.

Top: After completing its dive an Osprey must secure the fish underwater before starting to lift it free. *Middle:* Getting out of the water after catching a fish requires a lot of energy for an Osprey. *Bottom:* Flexible wingtips provide much of the lift. Connecticut, USA.







A male Osprey delivers a fish to its three young, about fifty days old and almost ready to fly. Such feedings will continue for another month or more, while the young gain competence on the wing and gradually learn to catch fish on their own. Sweden.

bits of evidence that can be checked against reference collections and the fish species often identified.

There has been an important new development in the study of Osprey foraging and diet. Individual birds tagged with satellite transmitters have opened up an exciting new window on where Ospreys find their fish, how big a range they cover before they catch one, and what time of day and how often they fish. It is hard to exaggerate how much we are starting to learn from this satellite technology, a subject we cover in more detail in chapter 6.

Although most Ospreys fish nearly every day of their life, there are some important exceptions. When nesting, females depend largely on their mates for food for at least four to five months, a period when males are doing double duty, feeding themselves and their mates in addition to providing enough food for their nestlings once they hatch. Typically, a female with an established mate will arrive back at her nest after migration, meet her mate there, and never catch a fish until her young fledge. Soon after that she leaves on fall migration and is back on her own. But for almost half the year she could be considered a "parasite" on her mate, although of course she's making vital contributions to the care and well-being of eggs and young.

In migration Ospreys may go days without fishing. Most migrants do fish along the way, but crossing oceans and deserts leaves them little choice but to fast and keep flying. Ospreys must perch to feed, and with no place to land on the ocean, and few if any fish accessible in those deep waters, even a hungry Osprey has to wait for a coastline. And one has only to look at photos of the Sahara Desert, which many European migrants transverse each year, to be reminded of how inhospitable that vast wasteland is for a fish-eating bird. So by necessity fasting is part of every Osprey's repertoire, reminding us what tough and resilient birds these are.

THE HUNT

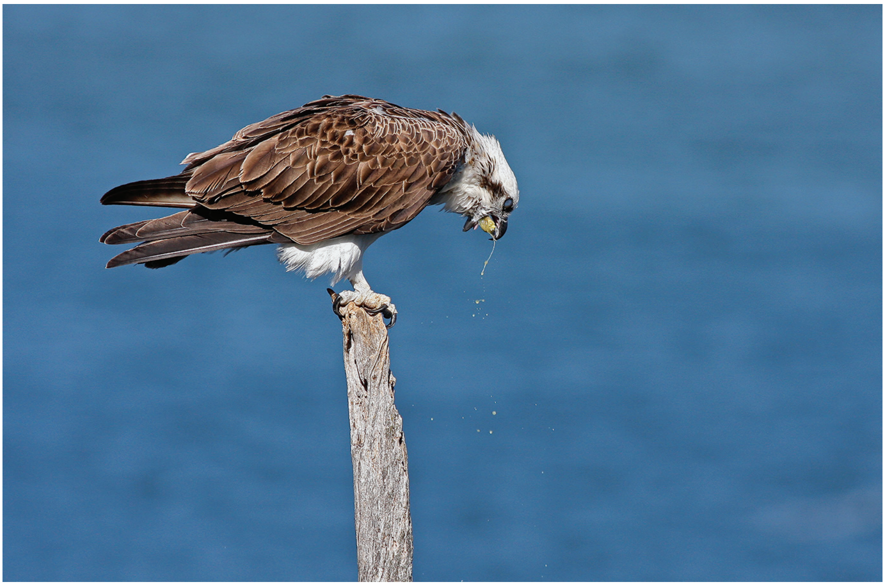
Photographer friends of mine were eager to film Ospreys catching fish along the coast of New England, USA, in an area that held a loose concentration of Osprey nests, about ten to twelve in all. They had been frustrated in their filming efforts because the fishing birds were dispersed and hard to find. So their solution was to buy a few tubs of live fish from a local commercial fisherman and dump those in a small coastal pond, creating an artificial bonanza. After that they sat back, hidden in a blind, and watched.

What happened was beyond their wildest dreams. They had expected a few Ospreys might find the fish in a day or two. But in thirty minutes the first Ospreys were there, hovering. Minutes later they were seeing simultaneous dives, two or three birds at a time, one bird even emerging from the water with a fish in each foot. And the Ospreys kept coming. In less than half a day, at least a dozen had shown up. The photographers were thrilled, and they managed to get excellent footage of diving Ospreys. But to a biologist this was a revealing moment. Seeding that pond with hundreds of fish was an experiment in determining just how efficiently Ospreys discover new foraging sites.

How did these local Ospreys find those concentrated fish so quickly? We know that this was not an isolated example. In dozens of other locations Ospreys have proven extraordinarily adept at finding new sources of food, particularly fish that are easy to catch. Newly formed fish farms, schools moving out of oceans and lakes into spawning rivers and ponds, wind-blown fish clustered along coastlines—time and again studies have shown Ospreys zeroing in quickly on such bounty in areas as diverse as West Africa, England, and Nova Scotia.

Foraging Ospreys are explorers, quick to recognize productive habitat, and they have the advantage of keen eyesight, a broad perspective on landscapes from the heights at which they fly, and (perhaps most important) what appears to be keen, well-developed memory. We know that individuals tracked by satellite transmitters, for example, often return to foraging spots they frequented months or even years before.

There is good evidence that Ospreys learn where to fish by watching each other, seeing individuals diving for fish and then heading out to join them. Perhaps more remarkable is the finding that in some colonies successful foragers coming in with fish may trigger others to head off in that same direction, even when no fishing birds can be seen. In this way Osprey breeding colonies become "information



Indigestible material in an Osprey's crop is often regurgitated as a pellet—a rare occurrence even for those who watch these birds regularly. Adult female, Western Australia.

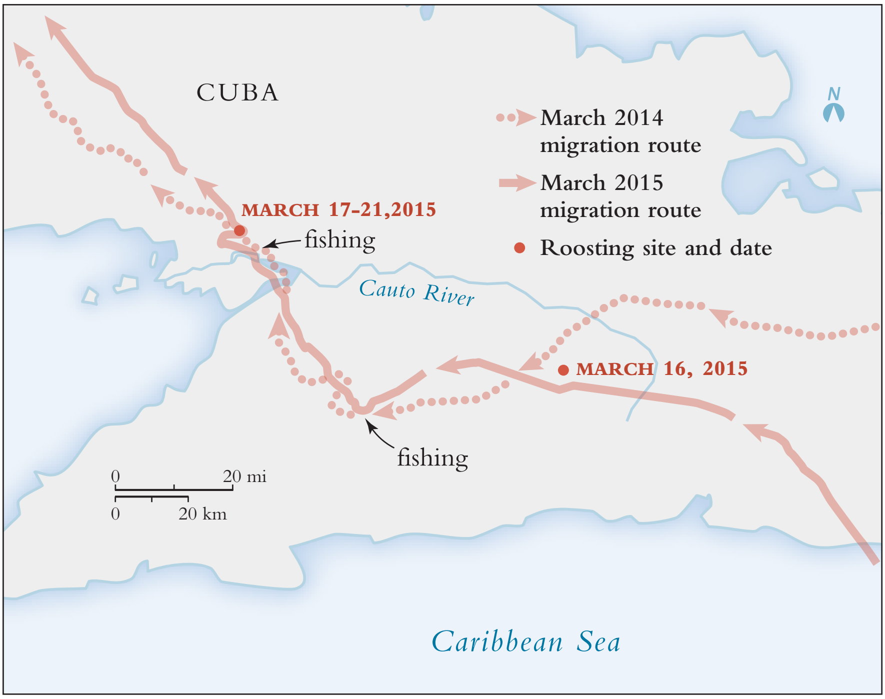
centers," a benefit of nesting close together. One Nova Scotia study suggested that Ospreys in colonies may even distinguish the kinds of fish neighbors bring in, setting off on foraging trips only when schooling fish arrive in the talons of colonymates, fish known to be clustered and easy to catch, but staying put (essentially ignoring the information) when they see other less-accessible fish coming in.

In short, Ospreys are masters at finding fish, especially at locating concentrations of them. But that is just half the battle; they still have to catch the fish, which brings a different set of challenges. Few sights in nature are more dramatic than a diving Osprey, committed and in full plunge, feet thrust forward and eyes lined up behind open talons, zeroing in on a fish. If you watch an Osprey hunt over open water you can often tell when it sees a target. Flight slows, wings beat at a more measured pace, the beats often stopped as the bird circles and glides, perhaps 100–150 feet (30–45 meters) up, looking down, its gaze intent. It might break the glide to hover, depending (apparently) on how accessible the prey is. But if the fish appears vulnerable, the Osprey often starts to drop down, moving closer, like a slow descent down a staircase, stalking its prey, hovering all the while. Then, in a split-second, it commits—tilting its body forward, wings folded, letting go and giving in to the full force of gravity, feet swung up toward the head and lined up in front of the eyes. Those talons are both net and spear—wide open, razor sharp, and extraordinarily effective at trapping a fish.

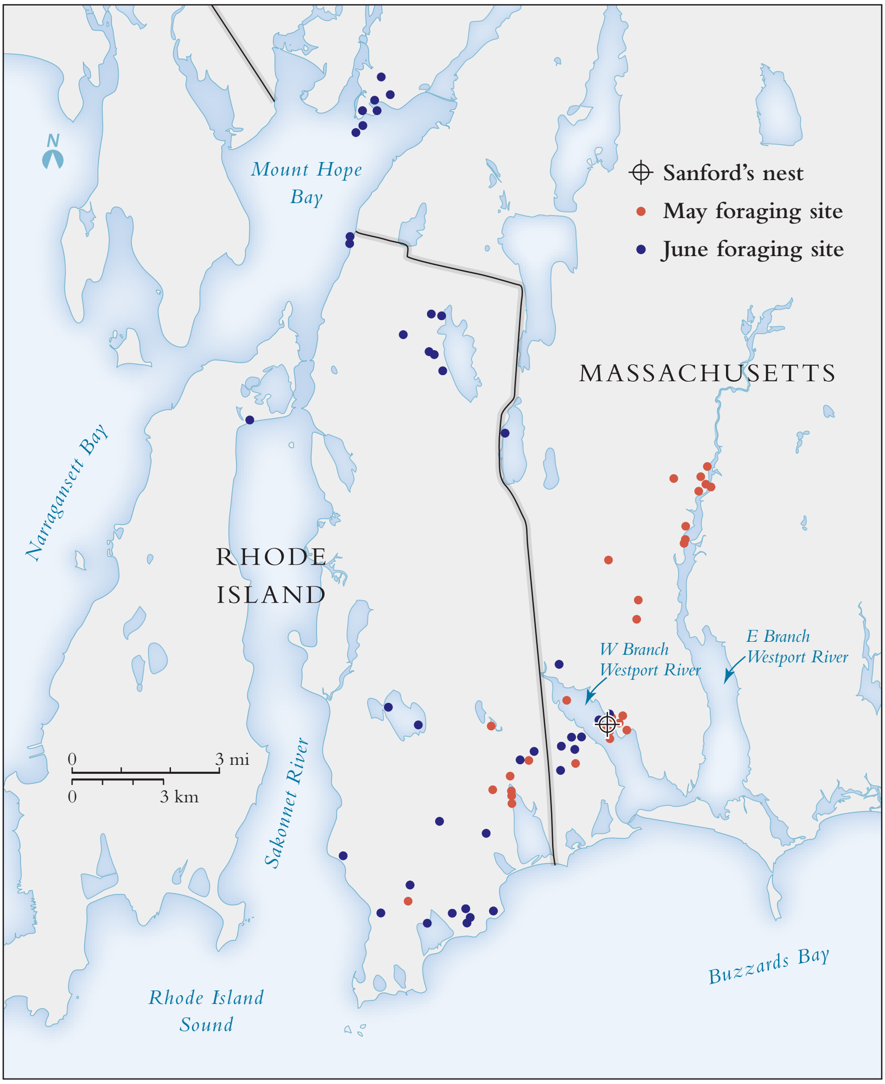
Keep in mind that fish are often moving and may rocket away if they spot an approaching hawk, so there is often adjustment as the Osprey descends, especially at the last minute as a fish breaks for cover or for deeper water when it sees a shadow overhead. In those cases dives are often aborted, the Osprey pulling up at the last minute and then regaining height, circling back for another try. But they are persistent hunters and more often than not will work an area for several minutes before giving up and moving on.

Ospreys have a big advantage over fish, in addition to their aerial perspective, their fast dives, and their enormous feet and talons. Their eyesight is extraordinarily keen, with an ability to resolve detail that is at least three to five times what our own is. This is partly because their eyes are large but also because those eyes have high acuity owing to regions on the retina (called the fovea) where photoreceptors, cells for detecting light, are especially dense. This may be particularly important when trying to strike prey under water because light bends (refracts) as it passes into water, so objects under the surface are not quite where they appear to be from the air. We do not know if diving Ospreys make adjustments for this. The fish Ospreys catch are usually large enough that refraction may not be a major factor in their diving. But they can certainly see much farther and better than fish, a decided advantage as an Osprey folds its wings and takes the final plunge.

Hitting the water and reaching well under the surface, the bird must lock onto the fish, with a split-second closing of the talons. This happens almost instanta-



Ospreys often return to the same fishing sites during their long migrations to and from breeding grounds, suggesting good memory. Here we see the tracks of Edwin, an adult male tagged with a satellite transmitter on his breeding grounds in the northeastern United States, as he migrated through Cuba in 2014 and 2015. Note that although the two flight paths differed year to year, they converged at the same fishing spots.


Mount Hope Bay
Narragansett Bay
MASSACHUSETTS
RHODE ISLAND
Sakonnet River
W Branch Westport River
E Branch Westport River
Rhode Island Sound
Buzzards Bay
N
0 3 mi
0 3 km
⌖ Sanford's nest
● May foraging site
● June foraging site

Tracking foraging Ospreys with satellite transmitters has shown us how individuals shift fishing sites over time. Sanford, an adult male from coastal Massachusetts, USA, fished inland fresh waters in May, mostly for spawning herring, but saltwater coasts and estuaries in June, probably for menhaden.

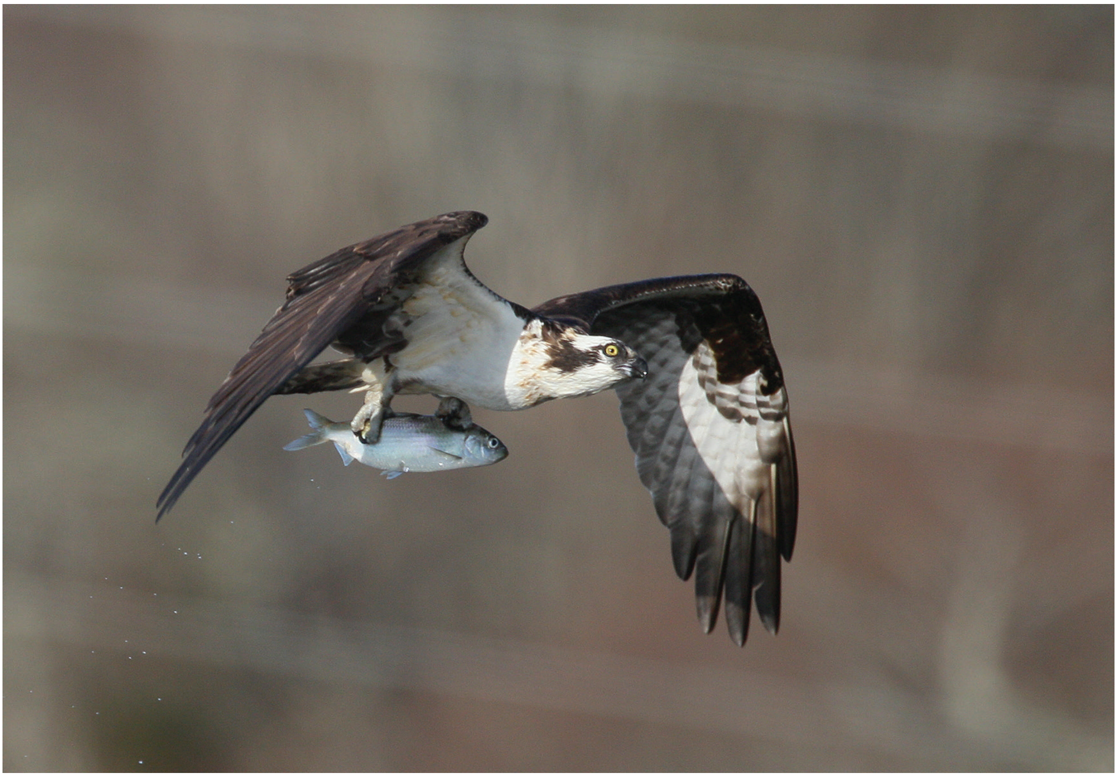
neously, probably a tactile response (triggered by the touch of an object) rather than a voluntary one (brain telling foot to close). Once in the water an Osprey cannot see the fish it has struck; it is feeling for it instead. So a bird will often pause for a few seconds after it hits the water, securing its grip, before beginning the laborious process of lifting free with a struggling fish in its talons.

BRINGING IT HOME

Lifting a fish from the water is tough work. Not only is the fish fighting to stay in the water, thrashing hard while wounded but also the Osprey has to overcome the inertia of its own arrested body. Here is an aerial creature stuck motionless in water, its plumage starting to get wet and heavy. What comes to the rescue is the Osprey's wing. Long and relatively narrow, with the outer wing exceptionally flexible, the wings reach high above the bird's head, gaining lift on both forward and backward strokes. Seen in slow-motion video, the outer wing looks a bit like a helicopter blade, and in fact the wing joints are flexible enough to allow for lift on both forward and backward strokes. Little wonder the US military named its recently built helicopter-like aircraft the *Osprey*, apparently in the hope that it could rival the bird's efficiency in take-off and flight.

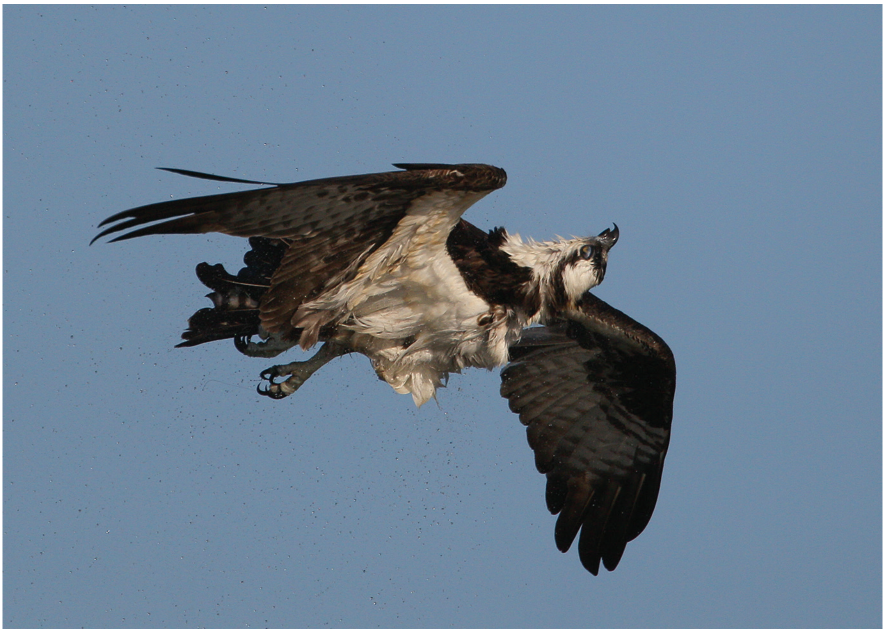
Once airborne and free of the water, a successful Osprey carrying a fish usually does three things. First it may shake like a wet dog, twisting from side to side in the air to free its plumage of excess water, a distinctive maneuver that seems unique to this bird. Then it almost always rearranges the fish in its talons so the head points forward and the tail back, and uses its flexible outer toe to grab the fish more securely with two claws on each side. After that, the fish secure and aerodynamically arranged, it heads for its nest or a feeding perch.

Feeding perches are an important part of an Osprey's landscape. The birds need to find a solid landing place where they can hold the fish down with their feet and tear it apart—a bare branch, a protruding rock in an open field, the crossarms of a power pylon. On treeless open marshes, Ospreys readily accept artificial perches that are built for them. In areas where the birds settle for nesting or overwintering these perches become a central part of their lives. Most individual birds use the same perch repeatedly, essentially taking ownership and defending



Ospreys nearly always carry their fish head first, helping to streamline flight. Massachusetts, USA.

An adult male Osprey gets ready for flight along the coast of Belize. Ospreys here are resident year-round.



Shedding water after a plunge. Such midair shaking and twisting is, among birds, behavior unique to Ospreys—even though your wet dog might do the same thing, albeit with all four feet firmly on the ground. Massachusetts, USA.

it, sometimes year after year. When looking for a particular bird, its perch is where you are likely to find it, day in and day out, and every night. This is especially true for breeding males, who tend to avoid the nest except to deliver food, preferring to roost nearby on their favorite perch. I take great satisfaction in examining these perches when I find them, not only for the fish remains underneath but also for the patina that develops over time on the surface—a branch sanded down over years by rough Osprey feet, painted with fish blood and scales.

Once at a feeding perch, a fish secure in its talons, an Osprey will often pause for a minute or two, the fish still giving an occasional flip of its tail, its dying throes locked in by the power of foot and claw. Then the bird gets down to the business of feeding, killing the fish in the process, if it isn't already dead. A feeding Osprey nearly always starts with the fish's head, often ripping the gill covers off first, dropping them because they are too big and bony to swallow, and then consuming the gills underneath. Brain and cheeks may be the first flesh consumed. From there it is on to the body of the fish, where flesh is concentrated. Guts are generally discarded; it is flesh that Ospreys want, not undigested stomach contents. Liver, and especially eggs/roe (when available), appear to be relished. I often find roe from spring-run herring (*Alosa* species) smeared on feeding perches, the Ospreys unable to pick up all of the tiny, sticky eggs. Fat-rich, these eggs are an early season bounty, a dose of vital calories for female Ospreys trying to grow their own eggs.

DIVE SUCCESS

Ospreys may be master hunters but they do not catch a fish on every dive. After all, fish are quick and elusive, often living in murky waters where rocks and plants and dead branches provide niches to dart into and hide. Because they hunt in the open, and because it is easy to tell when an Osprey catches a fish (emerging from the water with a struggling object in its talons), this is one aspect of the bird's life that has been particularly well studied. For one thing, we know that success varies with weather. On Florida lakes, for example, one in three dives was successful (caught prey) in all weather conditions, but success dropped by two-thirds when the sun was covered by clouds, and by half when the wind picked up, rippling the water surface. Such conditions made for more hovers, fewer dives, and less success. It seems that with reduced visibility the birds spotted fewer fish and were less likely to dive, and less likely to be successful when they did.

Given these challenges, Ospreys are adept at finding water conditions that help them spot prey. When spring gales blow through my area, I often see Ospreys, four or five at a time, lined up over calmer ocean waters along a lee shore, out of the wind. It seems these birds know how to find spots where winds will have the least effect on the waters they fish.

Ospreys find some fish easier to catch than others. Studies have shown that Ospreys routinely caught bottom-feeders—fish such as mullet or catfish or carp—on fewer dives than they did fast predators like trout or barracuda. Bottom-feeding fish look down for their food and tend to frequent shallow waters, often moving slowly, all disadvantages when trying to escape a predator diving from above. In addition, schooling fish appear to be much more vulnerable to Ospreys than fish that forage alone. Not surprisingly, dives are more successful when fish are bunched—the proverbial "fish in a barrel." Missing one fish, a bird can make a split-second decision to reach for another member of the school. We see this especially dramatically along the US Atlantic coast when vast schools of menhaden, a filter-feeding fish (see below), move into bays and estuaries in summer and become the favored prey of Ospreys.

We can learn a lot about Osprey foraging success by seeing how young birds develop this critical skill. Fledglings are fed by their parents for weeks, even months, after they learn to fly, so they do not have to become experts overnight. Studies at US lakes in Florida showed young attempting to catch fish as early as five days after their first flight, with the first success 11 days after; overall, however, fewer than one in ten dives produced fish at this stage. After that, success rates increased from about 20% of the dives 30 days after fledging to about 60% 150 days after, almost the adult level at that point.

DIET

Ospreys are so diverse in their choice of habitats, and cover so much of the globe during their wanderings, that it is difficult to generalize about their diet. Although the total number of species they are known to catch is large, certainly numbering in the hundreds, within any one region it is usually just a few species that make up the bulk of the diet, although this often changes seasonally, especially in salt waters.

Ospreys are nothing if not opportunists, rarely choosy in the fish they take, focusing instead on those that are most available. Along the south coast of New England, anadromous (sea-run) fish, mostly herring, are a critical part of the diet when Ospreys arrive back at their nests in early spring. These fish swim out of the Atlantic, up freshwater streams and into ponds to spawn, and historically were available in the countless millions each year—"running silver" is how those rivers were described in colonial times, before dams and overfishing took their toll. It staggers the imagination to think of how many fish were available to Ospreys in North America before Europeans arrived to decimate coastal fisheries. And a thousand years earlier European rivers had equal bounty. Today, in the Americas, just enough of these fish survive in catchable numbers to launch Ospreys into egg laying each spring, with a few other species (especially flounder: *Pleuronectidae*) filling in the gaps. By summer in New England, herring have dropped out and the Osprey diet becomes more diverse.

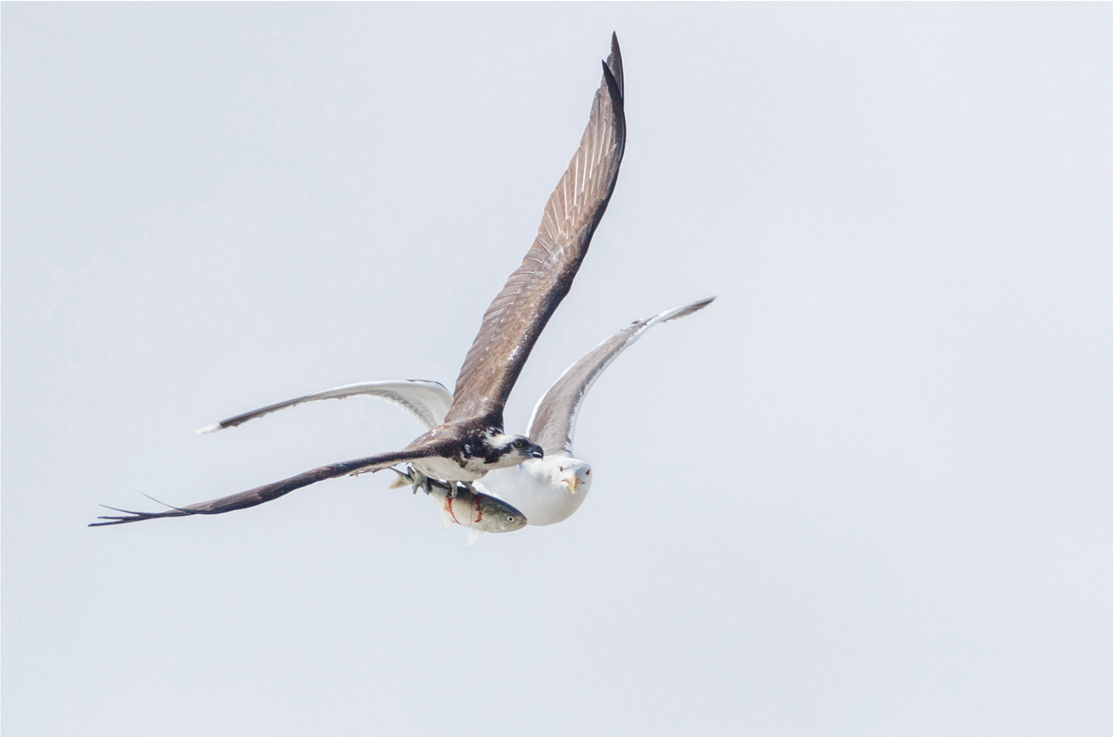
In western North America, trout feed a lot of Ospreys, especially the ubiquitous rainbow trout (*Oncorhynchus mykiss*), which are often raised in hatcheries and released into streams and lakes. In warm-water marshes and lakes, suckers (*Catostomus* species) and bullhead (*Ictalurus* and *Ameiurus* species) support many western US Ospreys, along with a handful of other species such as carp (*Cypriunus* species) and shad (*Alosa sapidissima*). What all these species have in common is a tendency to live much of the time in shallow waters, and to be (with the exception of trout) fairly sluggish and slow moving—all advantages to a foraging Osprey.

In Europe, trout and carp are also key species, with many of these fish often escaped or released from farming operations. Bream (in particular the common bream, *Abramis brama*) are likewise found in Osprey nests throughout Europe, along with roach (another carp relative), often taken in late spring and summer when they come into shallows to spawn. All are freshwater fish—from ponds, lakes, canals, and slow-moving rivers—with only a few European Ospreys dependent on coastal marine fish such as flounder and herring.

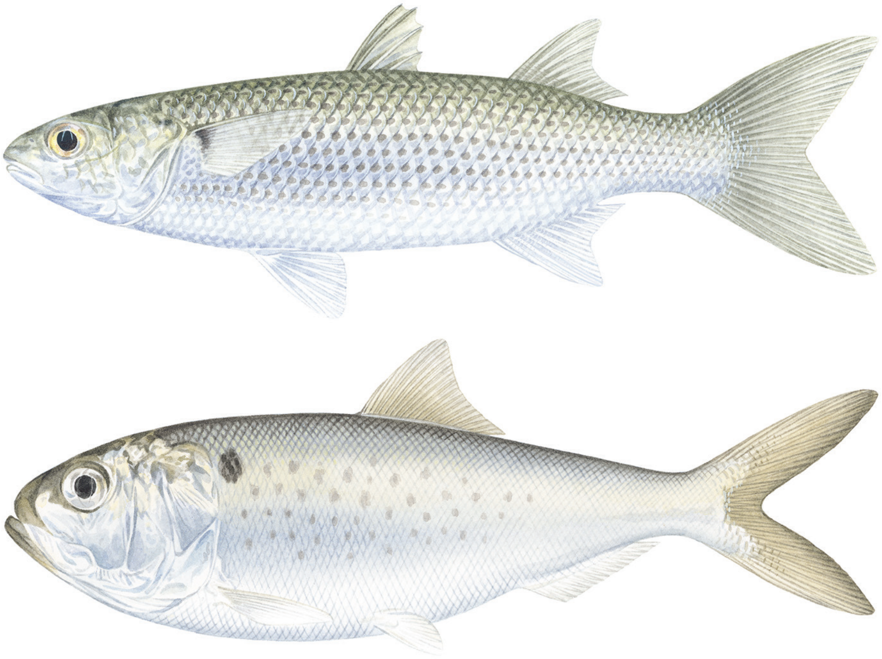
A TALE OF TWO FISH: MULLET AND MENHADEN

As one scans the Osprey diet for fish these birds would be hard-pressed to do without, two fish (or groups of fish) top the list: mullet (*Mugil* species) and menhaden. These are both primarily saltwater fish, so not all Ospreys rely on these species, but many do—probably at least half the global population at some point in their yearly cycle. Few Northern Hemisphere Ospreys wintering along saltwater coasts are likely to go a week without picking up a mullet or two. They are superabundant fish, especially in tropical and subtropical seas, and often swim in large, accessible schools, usually in shallow water. It would be hard to invent better prey for Ospreys. Although menhaden have a more restricted range, confined as they are to the US Gulf and Atlantic coasts, they too are usually found in enormous schools and in shallow water, and are Osprey favorites. An offshore species in winter, menhaden arrive back inshore at a critical time—when Ospreys are starting to feed their young. Their range overlaps that of North America's densest Osprey nesting concentrations, the Maine to Florida coastline.

Let's start with mullet. It might be an exaggeration to say that ten thousand Ospreys eat mullet every day, but that number is probably not far off, especially when considering the months when Ospreys breeding at northern latitudes have migrated south to the tropics. With the mullet's broad range and vast numbers, its tight schools in accessible waters, and the tropical center to its range, it is a fish that most Ospreys are likely to encounter at some point in their lives. There are more than fifty species of mullet worldwide, but a few are Osprey favorites, especially the striped mullet (*Mugil cephalus*). This is a widespread and extraordinarily abundant fish found in coastal waters at temperate and tropical latitudes from Australia to the Red Sea to West Africa, and from the Mediterranean to the Caribbean to Brazil. Range maps show its overlap with Ospreys in many areas, in particular with Osprey wintering concentrations along the coasts of West Africa and northern South America, and with nonmigratory breeding populations in the Red Sea, the Mediterranean, and the Caribbean. Some mullet also reach the south coast of England (three species, all known as Grey Mullet), where migrant Ospreys target them so regularly that the bird is known there as the "Mullet Hawk."



For an Osprey, catching a fish does not always mean keeping it. Large gulls, like this Herring Gull (*Larus argentatus*), are known to steal fish from Ospreys, although it happens rarely in most regions. Connecticut, USA.



Top: Striped mullet. *Bottom:* Atlantic menhaden.

A mullet is an oddly shaped fish, with a blunt nose, small mouth, and a flattened body, bluish-gray to green above with silvery spotted sides. They grow to almost 40 inches (100 cm) in length but most are smaller, 10–15 inches (25–38 cm), the size that Ospreys favor. And there are a lot of mullet in the world. We'll never know true numbers, but it would be safe to bet that, combining all mullet species, populations range into the hundreds of billions globally. To give some idea of the sheer global biomass of mullet, human catch statistics are often given in millions of metric tons. In Florida alone, almost twenty-five million pounds were netted in one recent year, with large fisheries for food and bait along the coasts of Africa and Asia as well.

Ecologically this is a cornerstone species, an important converter of small zooplankton and decaying plant matter, a fish that sucks up the top layer of sediments on sandy and muddy bottoms in shallow-water estuaries. This makes it a key link in the waters it inhabits, turning dead and decaying plant matter into flesh accessible to Ospreys and other fish-eating animals, flesh that is high in fats and energy rich. When we take an ecological perspective and look for ways that sunlight becomes transformed into Ospreys, mullet are a vital link in that process.

I got to know mullet firsthand during the three winters I camped along the shores of Florida Bay, in Everglades National Park, where I had started one of my first Osprey studies. To my surprise, I heard these fish before I ever saw them. Camped along the shores of that bay, I was awakened at night by the whooshing breaths of dolphin (*Tursiops* species) and the frantic splashing of the mullet they were herding into the shallows. This was the marine equivalent of wolves chasing panicked sheep, or lions after gazelles. The dolphins were masters at corralling mullet against shorelines and decimating them. By day these packed concentrations would attract flocks of birds—plunging Ospreys, pelicans, and gulls. Such feeding melees were one of those sights you never forget, a dramatic reminder of how many animals the mullet were feeding and what a rich, wild ecosystem they helped create.

Likewise in Senegal, West Africa, European Ospreys wintering along the seacoast depend heavily on mullet, which make up about half of their diet. Mullet species vary there according to habitat, especially the salinity and temperature of water, but again it is shallow, turbid, productive waters with muddy bottoms that nourish these fish and it is foraging dolphins that help concentrate the fish, giving Ospreys access to a vital package of protein. Eastern Australia and coastal Brazil: there too mullet provide more than half the Osprey diet in areas that have been sampled year-round. In short, it is probably safe to say that at least once an hour, at any time of day, any day of the year, somewhere in the world, an Osprey is eating a mullet.

Menhaden, unlike mullet, feed more by filtering the water around them than grazing the bottom under them. They vacuum up suspended algae and tiny larvae of zooplankton in their enormous mouths and then filter those particles with modified portions of their gills. So here again we see a fish that feeds low on the food web providing a vital link in converting plankton to food that predators can depend on.

Menhaden are found in concentrations that stagger the imagination. Fifty years ago there were reports of schools 5 miles (8 km) in diameter! Even today, despite intense pressure from fisheries, schools a half-acre or more in size are not unusual. From a distance these packed fish make the ocean seem to be flashing millions of tiny mirrors, the sun glinting off their scales as they mill about the surface. Large predatory fish slash at these schools from below, helping to concentrate the prey, and Ospreys join other birds—gannets and pelicans and gulls—diving from above.

A common summer sight along the US mid-Atlantic and northeastern coasts is an Osprey flying in from bay or ocean with a gleaming menhaden clutched in its talons. Historically, we now know, huge colonies of nesting Ospreys depended on menhaden along these coasts. Perhaps best known was the colony of three hundred nesting pairs on Gardiner's Island, a wilderness preserve about 5 square miles ($13\ \text{km}^2$) in size off eastern Long Island, New York. In its heyday, 1880–1950, the Gardiner's colony was the largest and densest Osprey nesting concentration in the world, fueled by vast schools of menhaden that massed in waters around the island each summer. Commercial fisheries could not leave a bonanza like this alone, moving in during the mid-1900s on an industrial scale and soon reducing this flood of fish to a trickle. Gardiner's Ospreys, hit hard by DDT contamination, struggled to regain their numbers without the menhaden bonanza. Surrounding areas, with more shallow water and a greater variety of fish available to them, saw exponential growth in Osprey numbers post-DDT, while Gardiner's lagged behind.

We see here an interesting symbiosis of fish and bird, with the health of a local Osprey population reflecting the health of the fishery supporting it. Menhaden also fuel an economically important sport fishery along this coast, worth billions of dollars each year. Pressure from these fishermen, with Osprey biologists joining in, has started to change the equation on industrial fishing for menhaden, raising people's consciousness on the value of a forage fish and helping to convince regulators to reduce fishing quotas. No longer are menhaden seen as just a component of fish meal and fertilizer. People increasingly understand their value for wildlife, and Ospreys have helped in this conversation.

ENERGETICS AND EFFICIENT FORAGING: NOT ALL FISH ARE CREATED EQUAL

How much fish does it take to keep an Osprey going for a day? Or to raise a brood of two to three young? Answers to these questions depend not just on the size of fish that Ospreys catch but also on the species caught, because fish differ greatly in their energetic content—the calories each one brings to a nest. Few studies have looked at these differences, but it matters a lot. An Osprey's energetic balance determines if it can complete a migration, for example, or fledge three young instead of one.

Fish flesh is made up mostly of water (65%–85%), proteins (15%–20%), and fats or lipids (0%–15%). Fats are particularly important because, compared to proteins, they provide more than twice the energy an Osprey's gut can metabolize (9.5 kilocalories per gram of flesh versus 4.2 kilocalories). Thus the net energy available from fish varies mainly according to lipid content. In addition, some fish have more bones and less flesh than others, so Ospreys may discard 30% of one fish but only 10% of another. Take our own diet for comparison: maybe a nice chunk of grilled salmon and a peanut butter and jelly sandwich versus an equivalent amount of dried jerky and peanuts with shells. Clearly we'd walk a lot farther with that salmon and sandwich in our stomachs.

So it is for Ospreys. In Senegal, for example, fish that wintering Ospreys caught varied between 0.9% and 5.5% lipid, and 38%–65% in their edible portion. Not surprisingly, Ospreys there favored fish such as mullet that were high in lipids and had fewer bones. But in some areas and seasons the birds had to rely on the less nutritious fish. Given that these were wintering birds, with no mates or young to feed, the differences were not critical. Calculations showed that the hunting time needed to meet daily requirements were mostly under thirty minutes for male Ospreys and mostly under sixty minutes for females (being larger, they require more food), quite similar to what we see for North American Ospreys wintering in the Amazon. The rest of the day these wintering birds spent perched—preening,

A European Osprey catches a mullet on its wintering grounds along the coast of Senegal, West Africa. Mullet are a staple of the Osprey diet in tropical and subtropical saltwater habitats.

Salt marshes in the lower reaches of Chesapeake Bay, USA. Although these marshes provide important feeding habitat for Chesapeake Ospreys, upper (freshwater) portions of the bay have seen stronger growth in Osprey numbers in recent decades because fish there are more abundant and richer in calories.

digesting, resting—hardly a strenuous life and a reminder of why a northern Osprey makes the effort to migrate thousands of miles to those latitudes each year.

Compare this with populations raising young in Europe or the United States. Once a male begins to forage for a mate and nestlings, it is much more likely to hit energetic limits. The nesting males I study in southern New England, for example, need (on average) almost two hundred minutes a day to meet their own energetic requirements, plus those of a large brood (three young) and a mate, even though their hunting efficiency (kilocalories per minute hunting) is about the same as those birds wintering in Africa or South America. Compared to the thirty to sixty minutes a day that solo wintering Ospreys need to stay fit, that's a big difference.

These differences have consequences, even at the population level. A recent study of Ospreys in 200-mile-long Chesapeake Bay provides a fascinating glimpse of how differences in diet can propel differences in population growth. Chesapeake Bay is an estuary, which means that its lower reaches, near the ocean, are primarily saltwater, while its upper reaches, fed by rivers, are primarily fresh. Studies by Bryan Watts and colleagues found that fish in the lower reaches were 6% shorter, 34% less heavy, and 40% less energy-rich than those in freshwater areas. Growth in Chesapeake Osprey populations over the past few decades has reflected those differences, with numbers of active nests doubling every four to five years in much of the upper bay, but only every forty years in the lower.

Filling the gut. This juvenile American Osprey was photographed just before its first fall migration, laying on fat for a long flight south. Connecticut, USA.

A key fish for Ospreys in the upper bay is the gizzard shad (*Dorosoma cepedianum*), which spawns in shallow waters but is available all season long, providing 25% of the Ospreys' diet but 50% of their energy. Going along with that boost in energy were bigger broods, which in turn fueled quick growth in that population as those fledglings matured and returned to the region as breeders. So here we see how diet, including availability of just a single species of abundant fish, can help determine where Ospreys settle and how fast their numbers grow.

I started this chapter with a look at the extraordinary length of the Osprey gut, and went on to explore how these birds find and catch the fish to fill it. We have also seen how the Osprey diet varies with place and season, and why not all fish provide equal energy to these birds. Now we move on to look at Osprey nest sites, and more specifically their life at the nest. The reproductive phase of an Osprey's life is a critical one. Successful individuals are those whose offspring make it into the next generation and breed successfully. But it turns out that there are significant challenges to achieving this success.

FIVE

At the Nest

For almost half the year an Osprey’s life is centered around its nest. Nests are what these birds return to at the start of each breeding season, often homing in from thousands of miles away. Nests are where they find their mates, lay their eggs, and feed and protect their young, finally sending them out into the world fully fledged to start a new generation. Tethered to their nests, breeders have little choice but to settle in and make a go of it. In the off-season, after breeding, they can wander when fish become scarce or the weather turns against them. But once they have made a commitment to nest and eggs and mate, wandering comes at a cost, and a significant one: death of eggs or young or, perhaps even more damaging, loss of that nest to another Osprey. Good nests, and especially the sites to build them on, are in short supply, each nest a major investment in time and effort, so there is often fierce competition for them. After losing a nest it may take an Osprey a year or two to find another. And of course without a nest there is no chance for an individual to pass its genes along to the next generation, the critical evolutionary measure of success in any bird’s life.

We know more about the nesting period than any other part of the Osprey’s life mainly because breeders stay put for months at a time, so individuals can be observed day to day as they go about the challenging business of producing eggs and raising young. Studies in dozens of locations—British Columbia, Japan, New England, Chesapeake Bay, Florida, Scotland, the Mediterranean, and the Red Sea, to name the most prominent—have all focused on Osprey nesting, with a few locations legendary in the thoroughness with which they have approached the subject. At one site in Loch Garten, Scotland, teams of volunteers and researchers have observed a single Osprey nest in every breeding season since 1958, with detailed notes on daily aspects of nesting and feeding and breeding behavior—a unique achievement in the annals of ornithology. More recently, similar efforts have been underway at Rutland Water, Leicestershire, in the Midlands of England, where a newly established population of Ospreys has settled on a reservoir and

A traditional Osprey nest in the midlands of England. Oak trees, like the one supporting this nest, often have robust branches that provide good nest sites for Ospreys.

This female Osprey incubates while her mate perches nearby—typical behavior of the species during the egg stage at nests around the globe. Males provide food, help guard nests, and incubate during as much as 20%–30% of daylight hours. Western Australia.

in surrounding woodlands, with at least one nest monitored dawn to dusk by volunteers over the last ten nesting seasons. I stand in awe of the dedication that UK researchers and their naturalist volunteers have brought to these Osprey studies. No one else comes close.

Other nesting studies have focused for shorter periods of time but with equal intensity. My own research in New England, for example, gave me the chance to watch a series of ten to twelve nests over three different summers, nests close enough together that I could monitor three or four at a time simply by positioning myself in the right location. Such are the benefits of working with colonial populations of Ospreys.

To enhance our fervor, we are seeing a revolution in nest watching with the advent of online nest cameras (nest cams), empowering an army of virtual nest watchers. With a continuous video of the nest streamed over the web 24/7, from

RSPB
Welcome to the
LOCH GARTEN
OSPREY CENTRE

Top: The Loch Garten Osprey Center in Abernathy, Scotland, has been home to Osprey watchers since 1959, with well over one million visitors passing through. The Royal Society for the Protection of Birds (RSPB) oversees the Center and its Osprey nest. *Bottom:* Osprey viewing blind at the Rutland Water Nature Reserve in the Midlands of England. From here a nearby nest is monitored during daylight hours throughout the season, and hundreds of visitors stop in each week.

the day the first bird is back until the last one leaves, we can find real-time, close-up views of the lives of nesting Ospreys, often with hundreds of people tuned in to watch and forming comment groups to post their reactions. While the results have been extraordinarily successful overall, bringing Ospreys into the offices and living rooms of people who knew little about the species before, a few of the viewers have been unprepared for what they saw. When young starved, or turned aggressive in the nest, some in this virtual audience were shocked, demanding that cam owners intervene to "save" the nestlings.

So far we have seen little in the way of science emerging from these nest-cam efforts, although reams of data are there to be mined—hundreds of thousands of hours from perhaps a dozen nests over at least a decade. It's a trove of information waiting for the right students; let's hope they can be found in the decades ahead.

It is hard to overstate the pleasures of Osprey nest watching, even if it is just on a screen. My own preference is to head down to the edge of a tidal river that runs near my house and set up a chair and telescope, settling in for an hour or two to see the birds go about their lives. Nothing can replace the experience of being out there on a warm spring morning and gradually shifting over to "Osprey time." In many ways such observations are a study in meditation. One of the first things you discover is what unhurried lives these birds lead. While Ospreys do work hard for a few hours every day, especially when nest building or catching fish for growing young, much of their day is spent at rest, either perched near nests (males) or on the nest itself (females incubating eggs or brooding small young). There is no set schedule to an Osprey's life. Instead their activity seems to depend on weather or on growing levels of hunger or on a potential predator passing by that they feel compelled to chase. Tuning in to these daily happenings is to let oneself enter fully into the life of a wild animal, and to find the refreshing perspective that comes with that.

SPRING ARRIVAL: FINDING A NEST

For those of us who live where migratory Ospreys are part of the landscape, few sights bring a bigger lift than that of the first spring Osprey back at its nest. In southern New England, along the Atlantic coast, Ospreys start to appear in late March, when winter and spring vie for dominance. One day can be wet, cold, and dark, with a blustery wind off frigid ocean waters and even a brief snowstorm blowing through. The next day might dawn clear and bright, with soft winds out of the south and the ground thawing fast. Ospreys seem to materialize magically on such warmer days, and my experience of welcoming the birds back is common to Osprey enthusiasts around the Northern Hemisphere—from the lakes and reservoirs of the western United States and Canada to the forests of central Finland

Ospreys nesting at northern latitudes often encounter cold temperatures early in the season, after returning from migration. Early arrivers avoid competition for nests but have to burn extra calories to survive. Connecticut, USA.

and northern Scotland, and from the rocky cliffs of Japan to the coastal Atlantic marshes of Nova Scotia and the Carolinas. Like so many of our migratory birds that travel great distances to find the right habitat for nesting, Ospreys arrive, as the great conservationist Aldo Leopold put it so well, “carrying the conviction of an army that has burned its bridges behind it.” They are settling in for a long stay.

Seeing those first few Ospreys back at their nests makes me think of all they have left behind, and what they encountered on their flights north. After all, these birds left tropical rivers and Caribbean coastlines just a few weeks earlier, and there they are plunged into nights when temperatures often dip below freezing, with gale-force winds that can drive the cold deep into their bodies. Yet the Ospreys survive just fine, bolstered by warm plumage and by a steady burn of high-calorie fish in their guts.

Why do they bother to push so hard, friends ask me—why return so early, when waiting two or three weeks would land them into more benign spring days? The most obvious answer: despite the cold, there is food available to support them, often in the form of migratory fish moving in from the sea to spawn in fresh- or brackish-water rivers and ponds. Any earlier and those waters might be frozen, with the fish holding off at sea. But the Ospreys seem to have it timed just right. Likewise in Finland, Ospreys often arrive when lakes are just starting to thaw; despite the seemingly inhospitable habitat, the birds find spawning fish in the shallow-water margins between ice and land.

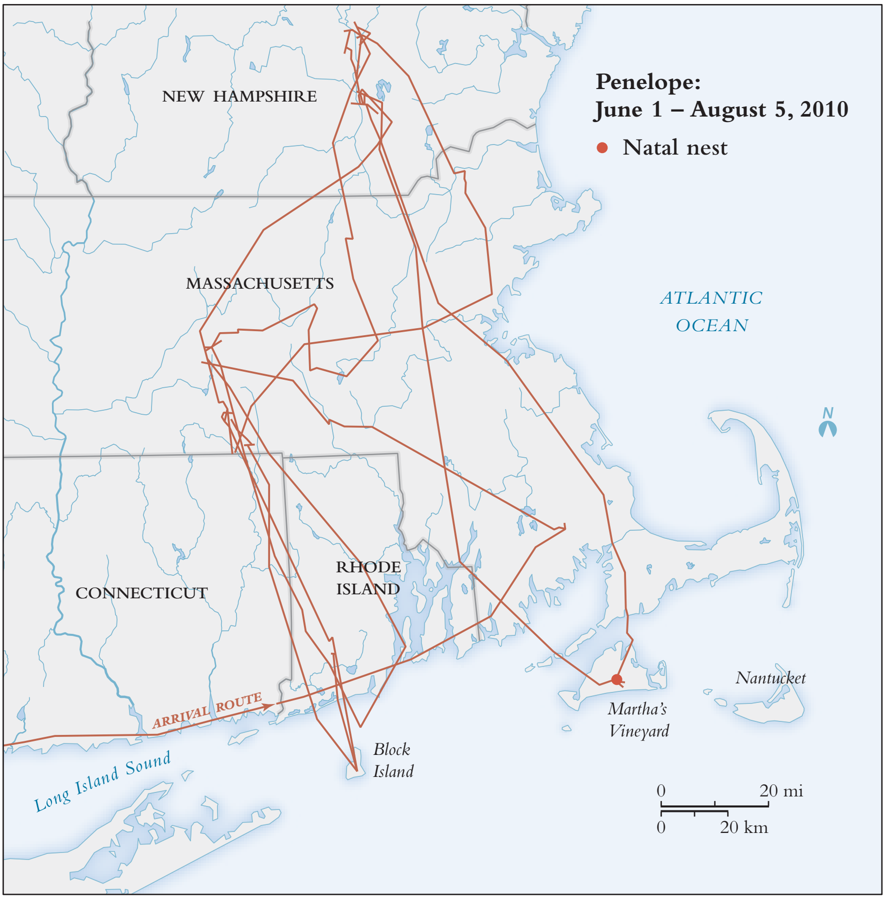
In addition, early arrival promotes successful breeding. Early birds get the nests, while late arrivals often find theirs usurped and must fight to regain them, wasting time and energy and potentially jeopardizing life and limb. Once established at a nest, an individual male or female has a good chance of attracting a mate, either theirs from the previous year or a new one if the old mate has died. Without a nest, or at least a site with potential to hold one, an Osprey has little to offer a mate.

Finally, young fledged from early nests are far more likely to survive their first year of life than are young from late nests, and far more likely to go on to become vital new members of a breeding population. This is because early young have a longer time to gain the critical flight and foraging skills needed to complete their first migration and to survive their first winter in a new land. So for a migrant Osprey returning to northern breeding grounds there is a balance to be struck: too early and food may be hard to find; too late and the bird may have to fight for a nest and its progeny are less likely to survive.

Keep in mind that not all Ospreys are migrants. Resident populations at subtropical latitudes—southern Florida and the Caribbean, Australia, the Red Sea and Arabian Gulf, and northern Mexico—all remain at or near their nests year-round. So for these birds, breeding schedules are more relaxed. As the nesting season approaches, pairs gradually drift back to nests from nearby, spending more time together there and perhaps even initiating nest repairs. Not surprisingly these birds breed over a longer stretch of time than their northern counterparts do, with eggs laid over a period of two months or more, instead of the two or three weeks of peak laying seen in most populations farther north.

Another group of Ospreys showing relaxed schedules are young birds returning to breeding areas for the first time. These slowly maturing birds do not begin a return migration until they are in their third calendar year—the second full spring of their lives—and they seem in no hurry to get north. They depart wintering grounds a month or two later than adults do, and often travel at a slower pace. Once they reach breeding grounds, they begin the search for a nest or a site to build one in. Because these can be hard to find, these young Ospreys tend to wander, often considerable distances. With luck, their wanderings bring them to a site they can claim, and they may even attract a mate once there. But more than likely they will fail at all of this and return in fall to their old wintering site, only to come back the following spring—earlier this time—and try again. In regions with many Ospreys and few nest sites, it can take two or three years for these birds to find a nest and a mate, a luxury of delayed breeding that only a long-lived bird such as an Osprey can get away with.

A glance at broad dispersal patterns in these birds shows us distinct sexual differences: females tend to settle as breeders considerably farther from where they were born than males do. Such patterns are typical for many birds, although why


Penelope:
June 1 – August 5, 2010
● Natal nest
NEW HAMPSHIRE
MASSACHUSETTS
ATLANTIC OCEAN
N
CONNECTICUT
RHODE ISLAND
Nantucket
Martha's Vineyard
Block Island
ARRIVAL ROUTE
Long Island Sound
0 20 mi
0 20 km

Finding a mate and nest site can take time for Ospreys and involve considerable wandering. Here we see the extensive travels of Penelope, a young female tracked by the satellite transmitter she was wearing, after returning to her natal area (Martha's Vineyard, Massachusetts, USA) for the first time, as a 2-year-old. Overall, male Ospreys tend to settle closer to their natal sites than females do.

this is so remains unclear. What's interesting about Ospreys is that their dispersal seems to reflect the availability of nest sites. Historically in parts of New England, where population numbers were low and many new artificial nest sites were built for the birds, they tended to nest closer to "home," about 30–40 miles (48–64 km) for females, and about half that for males. In the forests of Finland, by contrast, where good nest sites are scarcer, distances between fledging and first breeding are almost double that for females, although about the same for males.

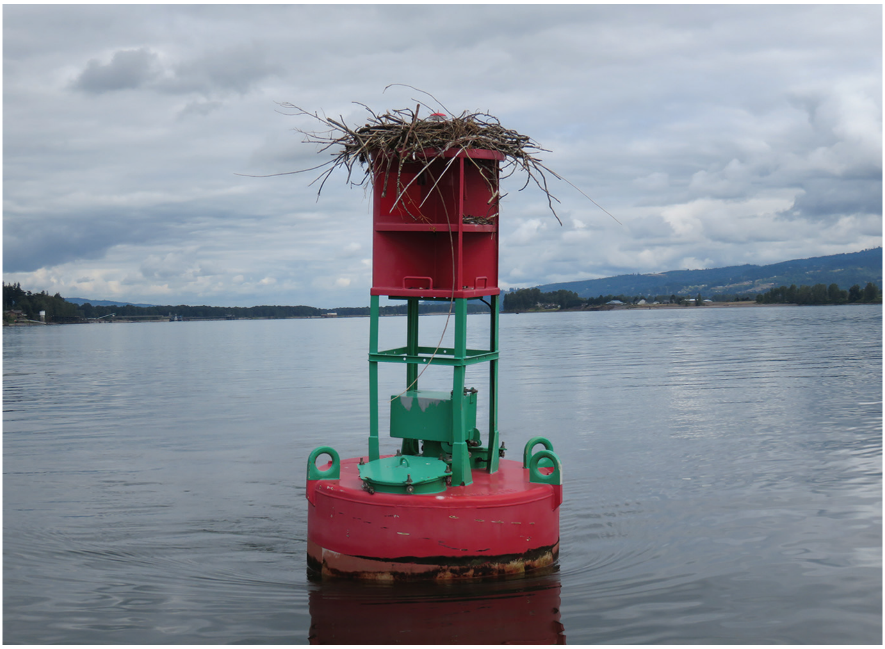
It is fascinating to think about what transpires in the brain of an Osprey that settles into a potential nesting area after a long migration. What is it looking for; what are the instincts that drive its behavior day to day? One thing is clear from watching these birds: finding a nest, or a place to build one, is paramount. The fortunate individuals are those that return to find the nest they used the previous year relatively intact. If the nest has survived the winter, and the owner is back in time to claim it, the transition is usually a seamless one. Ospreys are almost always loyal to their old nest sites, and why wouldn't they be? There is no reason to build a new nest, a big investment in time and effort, unless absolutely necessary. Their mate, if alive, will return to join them. The attraction of mates is as much to their mutual nest as it is to each other. Among adult Ospreys only about 10% die each year, so there's at least a nine in ten chance that a bird will get its mate back each spring. These are the lucky ones, and they waste no time in getting down to the business of producing eggs. In any Osprey population most pairs fall into this category.

Less fortunate are the birds that return to find their old nest destroyed—the nest tree blown over by a winter storm, a cliff nest tumbled by a rockslide, a goose or an owl that has moved in early to take the nest over, or even removed by humans because it was built in a troublesome location. In all such cases, the bird has no choice but to start over, either finding an empty nest (a rare occurrence) or, more likely, a place to build a new one. For pairs looking to build in trees, fewer than one in a thousand are likely to have what it takes to support a nest, at least in most regions. The best nest trees are those with flat tops and broad dense branches, a rarity especially in today's heavily managed forests.

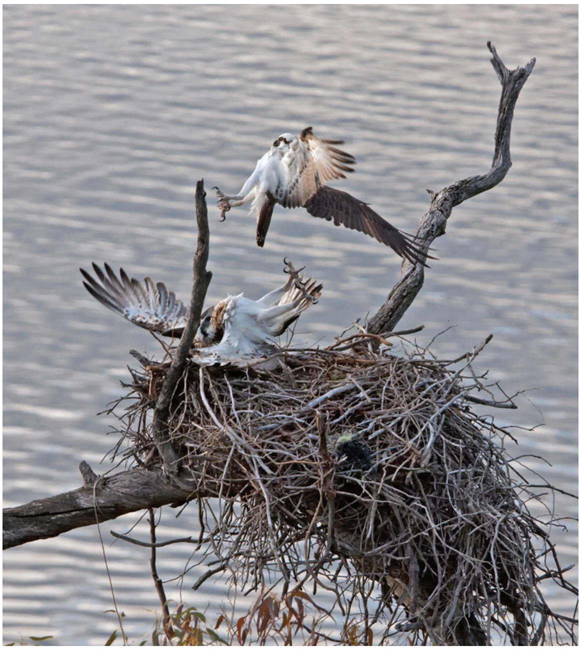
This is a key reason why artificial nest sites have become such a powerful lure for Ospreys. Many often exceed the best features that natural sites can provide: a stable base for a nest, protection from predators, and enough openness to allow Ospreys easy access as they come and go. Overwater sites often supply these needs most readily and as a result have a near magical attraction for the birds. Navigation markers on lakes and tidal rivers, recently flooded swamps or reservoirs with dead and dying trees, and small islands—all are ideal sites for nest-hunting Ospreys, as they are both open and protected by surrounding water, so the birds zero in on them. Historically many of the largest and densest nesting colonies have been on islands, especially those free of predators.

A common sight in Osprey country during the breeding season is a pair of birds, or a single one (often a male), on the hunt for a nest site. One sees them soaring over the landscape, often calling, sometimes attracting other Ospreys to join them, sometimes swooping down to perch in a spot for a few minutes, then launching back on the wing again. Often they will harass established pairs at nests, testing them to see if the owners have what it takes to defend their site. These spats can turn aggressive, but only rarely are the intruders successful in evicting the owners. Once a suitable site is found the birds usually settle in and begin to build a nest. Some build quickly but most, especially late in the season, seem to take their time, adding a few sticks here and there but finishing with only a rudimentary structure. The next season they are likely to return and spend more effort getting the nest ready for eggs.

Most nests need significant repairs after a season of storms and neglect, especially refashioning a shallow cup for the eggs, lined with grasses and other soft material. But the nest structure also gets attention, with males snatching large sticks from the ground, or breaking dead branches off trees with impressive dives, and lugging them back to the nest in their talons, where the female usually takes



Overwater nest sites have a near magical attraction for Ospreys, in part because of their openness and isolation from ground predators. Navigation markers like this buoy are favored sites for nest-hunting Ospreys. Columbia River, Oregon, USA.



Nests are a valuable resource, and good nest sites are hard to find. Ospreys often fight to defend their nests from usurpers, individual birds trying to take them over. Western Australia.

over and arranges the material, tucking it into the nest with her bill. So it is a team effort, this nest building, with the males doing most of the gathering and the females most of the arranging once the material is back at the nest. It is impressive how quickly a nest can be built, if the pair has the right site and is motivated. I have seen a pair settle onto a bare wooden nesting platform, one built specifically for the birds, and fashion a nest that is ready for eggs in three or four days. Admittedly, these are basic, rudimentary nests, but they suffice and materials are added to them season by season. In other situations, nests can take much longer to build, sometimes an entire season. And especially with a ground or cliff base, nests can become enormous. I have sat in a few such nests; they are impressively solid and hold my weight without a quiver. In some places such mega-nests become local landmarks, with one on a large rock along the coast of Maine in the United States now written into navigation charts for that region.

The variety of material that Ospreys incorporate into their nests is also impressive. They are true pack rats. While sticks and branches, clumps of grasses (or seaweeds and algae), and even clods of soil usually form the bulk of any nest, peripheral materials are abundant and can be a bizarre reflection of what is available in local landscapes. Where I live, for example, surrounded by farms and coastal fisheries, our nests are often laced with dried cornstalks and clods of manure, and it is not unusual to find discarded rubber teat-holders from dairy milking machines or plastic buoys and hunks of rope from lobster traps, along with rotting pieces of old fishing nets. Alas we find more and more plastics in the nests as well, especially discarded shopping bags, ribbons from party balloons, Styrofoam cups, polyethylene six-pack holders, and strips of weed-control plastic used in surrounding fields. Some of these can prove hazardous to eggs and chicks (see chapter 7).

By contrast, the nests I saw in remote forests of Scotland and Finland were pristine, much more likely to be lined with moss, or lichens, or clusters of pine needles or dried algae from nearby lakes. Show an Osprey researcher photos of

A sure sign of the start of Osprey breeding season is a male lugging a stick back to its nest. Males provide much of the material used to build nests; females generally arrange the material once it has been delivered. Leicestershire, England.

Getting a nest built or repaired is a key part of putting an Osprey pair on the road to eggs and young. Here, a male delivers new material to its nest. As nest building progresses, the birds shift from bringing sticks to softer grasses to line the nest cup for the eggs. Connecticut, USA.

nests from around the world and the odds are good they'll be able to pick out nests from their own region, just by looking at the materials that have gone into it.

FINDING A MATE

If the early nesting season finds Ospreys busy with nest building and repair, it also reveals something else on their minds: finding a mate. Building a nest is just the first step, while getting eggs into the nest is the ultimate goal, and courtship starts them in that direction. Stepping out of my door on a warm April morning, I cock an ear to the sky. One of the first things I'm likely to hear is the high piercing call of a male Osprey in the full glory of its undulating courtship flight, feet dangling and a bright silver fish clasped in its talons. This "sky dance" or "fish flight" is a conspicuous part of spring landscapes in Osprey country, and always a delight—a sure sign that spring is cracking open and a long winter is in retreat. It is the male Osprey's way of advertising his availability (and foraging prowess) to neighboring females that may be unattached, and likely also a way to alert nearby rival males that his nest is fully occupied.

Courtship flights can last anywhere from two to twenty minutes, but at the end the male usually dives steeply down and swoops up to his nest, presenting the fish to his mate. If his mate is a familiar one, he generally hands it off to her quickly; with a new mate, the transition can be more awkward, and take longer. Such feeding helps males ensure that their mates stay faithful instead of wandering off to copulate with other males, and it helps keep developing eggs in the female safe from the damage they might incur if she were to forage on her own. Once eggs are laid and young hatch, it is generally the female who defends them, so here again she is tied to the nest and must rely on a mate to bring her food.

Interestingly, it appears that courtship feeding may also be a way for females to judge the competence of the male they are about to settle in with. Males that bring plenty of food during courtship tend to be those that do the same during the critical period when young have hatched and are growing. Poorly fed females appear much less willing to copulate with a prospective mate, probably continuing to weigh their prospects during this all-important period.

There is nothing hidden about Osprey copulation; nests are usually in the open and pairs generally mate at the nest. But there are subtleties here. Close watching shows that a female often solicits copulations by tipping forward slightly with her body, her tail raised almost imperceptibly in the process. To be successful, the male needs to fly in and land on the female's back (which he does with surprising gentleness, talons closed and resting on his tarsi) and then scissor his tail under

The "sky-dance" of a male Osprey. These undulating courtship flights are hard to miss: bold, energetic, and vocal. They are performed to attract mates and help defend a territory. Leicestershire, England.

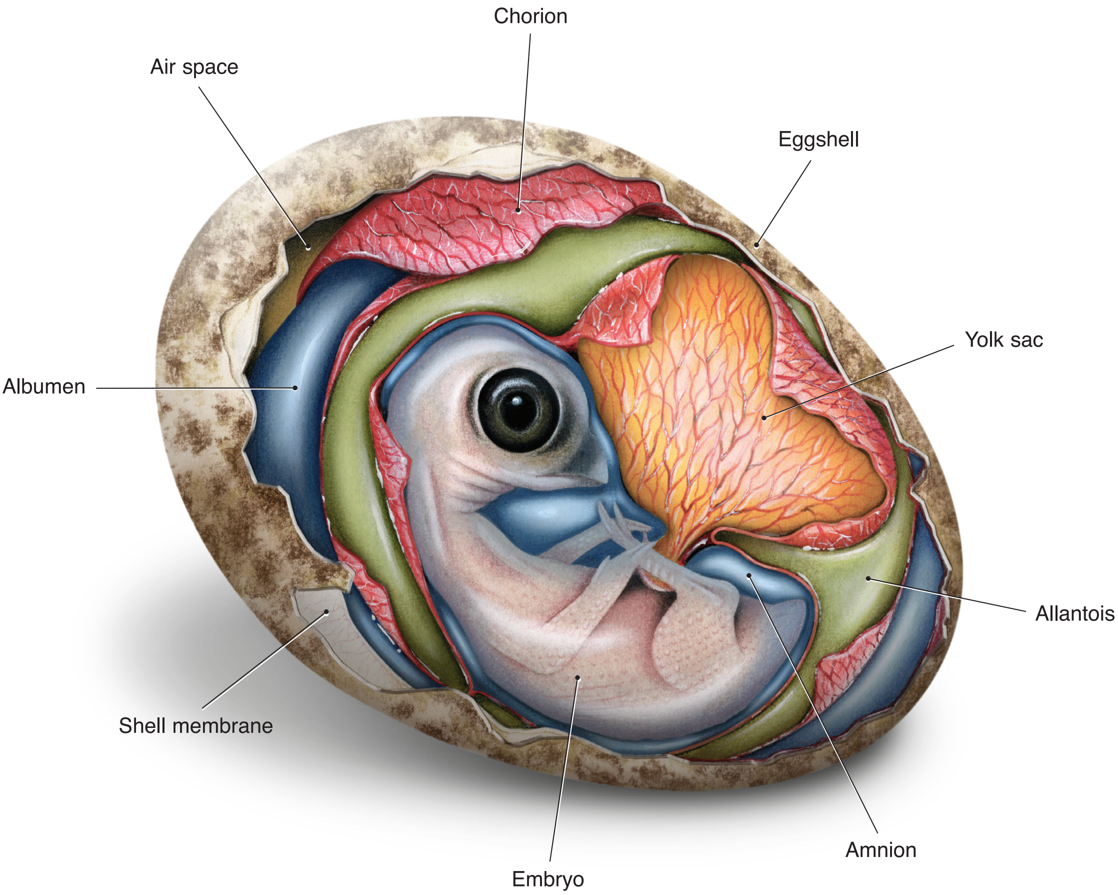
Established Osprey pairs copulate often, on average 150–200 times for each clutch of eggs laid. But only about one-third of these copulations are completed successfully. The closer a pair is to egg laying, the more frequent the copulations are. Western Australia.

hers so their vents can touch (the so-called "cloacal kiss" in birds). This contact is what ensures the successful transfer of sperm when the male ejaculates. But females seem to control the copulations—access and success. In the early season, when pair members are new to each other, or in newly forming pairs at any time, copulations often fail, the male shrugged off the female's back before he can get his tail under hers. But as pair members get more familiar to each other, and as females are fed more consistently, it all seems to go more smoothly. Males may try to copulate ten to twenty times a day, with about half of those successful. The closer to egg laying, the more likely the birds are to copulate.

Fertile eggs depend on sperm reaching a developing egg (ovum) in the female soon after it is released into her oviduct, and there is some suggestion that copulation in birds may help to stimulate the development of these ova and their release. In any case, once released and fertilized, the egg slowly descends the oviduct over a period of a day or two, along the way picking up albumen (the egg "white"), shell membranes, and then the outer shell itself, with pigment coloring laid on just before the egg emerges into the soft protective lining of the Osprey's nest.

INCUBATION AND HATCHING: FROM EGGS TO CHICKS

It is easy to take an egg for granted. They sit placidly in cartons on our refrigerator shelves, week after week throughout the year. But peering into the nest of a wild bird and seeing its first few eggs, newly laid and washed with the vibrant colors of fresh pigments, is to restore a lot of the magic that supermarket eggs may



An Osprey embryo develops inside an eggshell that keeps it from drying out but allows for air exchange. The yolk sac and albumen provide the nourishment that this embryo will use to grow into a hatchling.

have taken away from us. Look carefully at an Osprey egg and you can begin to appreciate all that has coaxed it into being: tiny follicles within the female, each the germ of a new egg, nurtured through winter by a tropical climate and fish; the long migration north to nest and mate, with the growing stimulus of male feeding and courtship flights and copulations, and perhaps even the nest itself, triggering a subtle flow of hormones within. That flow will swell follicles and release each ovum one by one, which becomes transformed within the female in the space of a day or two into a fertile, hard-shelled ovoid sphere with muted bay and chestnut washes of color that help to distinguish it from any other egg in the world. Emerging into air and nestled between the warmth of the female's belly and the soft lining of the nest cup, that egg, self-sufficient and alive, is poised to begin converting yolk and oxygen into a fully-formed chick that will hatch on a warm spring morning five weeks later.

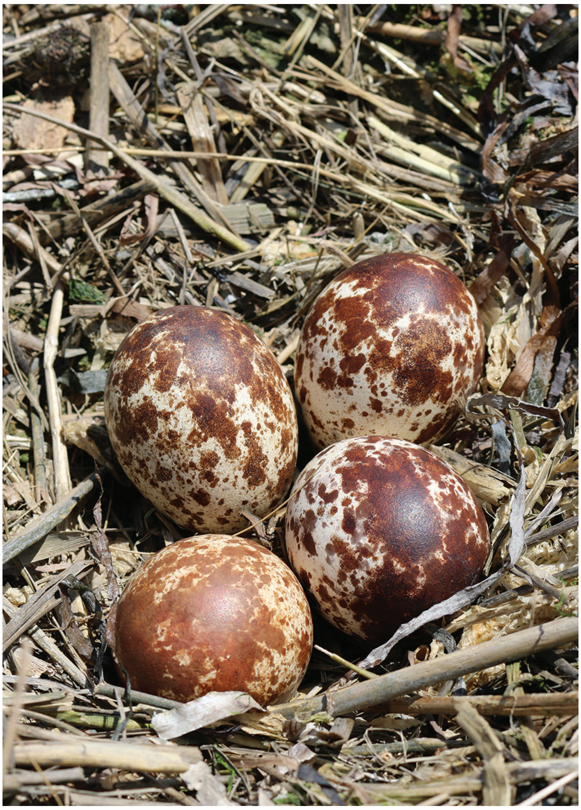
Most Ospreys lay three eggs. Two eggs are more prevalent at lower latitudes, where day length is shorter and parents have fewer hours to feed large broods, and in younger birds and late breeders—birds less capable of raising young.

Larger clutches of four eggs are rare but regular (10%–20%) in most northern populations.

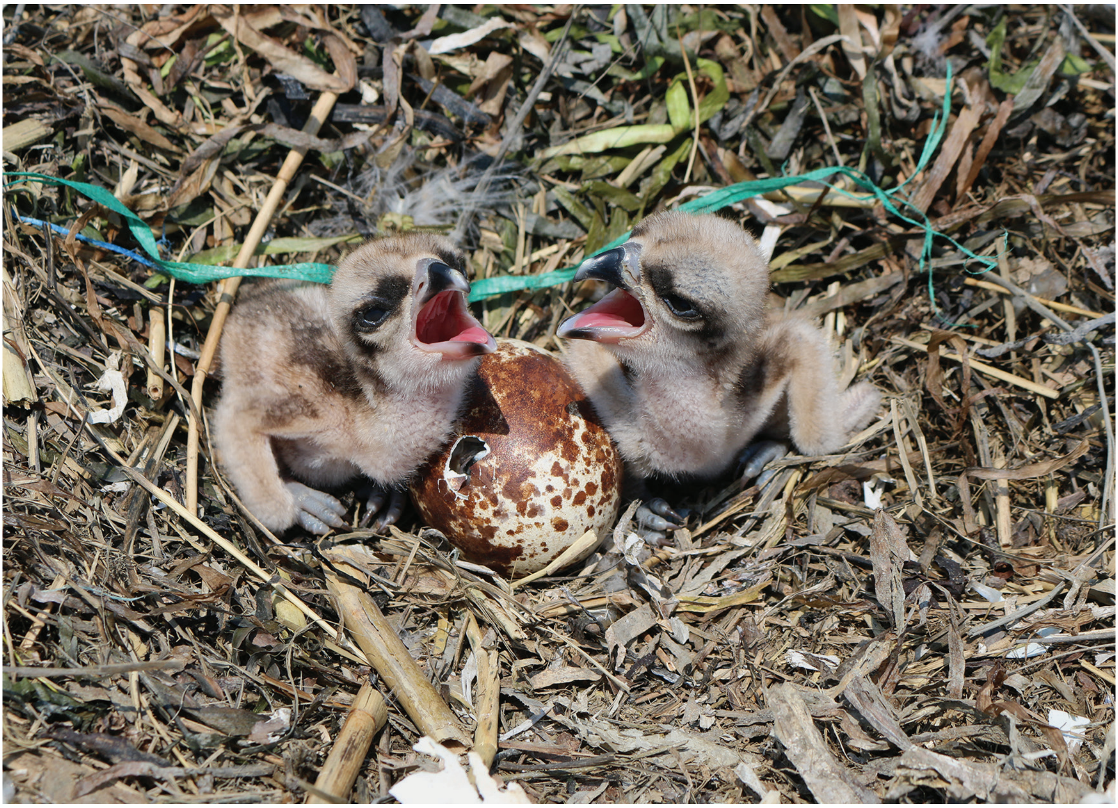
A century ago naturalists pursued egg collecting with some of the same zeal that birdwatchers today go after rare species for their lists, or photos to post on the web. Osprey eggs were favorites of these collectors, a much sought-after prize, and little wonder. Their subtle markings and their rarity set them apart. Today, researchers have discovered that, within a clutch, egg color and pattern tend to be consistent enough that we can often identify a female year to year by the colors and patterns of her eggs.

Ospreys typically lay their eggs a day or two apart, with the third egg appearing three to four days after the first. Because incubation often starts with the first egg, and eggs hatch in the order laid, this sets up a hierarchy in the ages of hatchlings, with the third chick often a half a week younger than the first, and the fourth chick (when there is one) almost a week younger. Hatching from a late egg means a chick is the runt of the brood, smaller than early nest mates, and this has significant consequences. The latest hatched young are far more likely to die in the nest, especially when food is scarce.

Once eggs are laid, Ospreys settle into five weeks of a fairly quiet life in between the flurry of early-season courtship and nest building and the urgency of



Typical Osprey eggs; overall pattern and color differ little among populations, although among individuals there is subtle variation, often enough to help identify a particular female by her eggs. Most pairs at northern latitudes lay a three-egg clutch; about 20% lay four. Massachusetts, USA.



Newly hatched Osprey young, about 1–2 days old, with an egg that is starting to hatch (*center*; note the small hole that the chick inside will enlarge before it emerges). Massachusetts, USA.

feeding young after eggs hatch. Females tend to do most of the incubating, with their mates helping off and on—some males more than others. Males continue to provide all the food, however, each one heading out from its perch near the nest on foraging trips only to return later with a fresh fish in its talons. Nest watchers can rely on finding a particular male at his habitual perch, tucking into a still-writhing fish, as it settles back in for a feed. Males almost always eat the front part of the fish first, the head and perhaps a third or half of the rest, and then fly up to deliver what's left to the female at the nest. As the male approaches and lands, the female rises gently from her incubation crouch and moves slowly toward the male, grabbing the remains of the fish in one foot before launching off to a nearby perch, often the same one the male has been using. There she will feed for as long as it takes her to finish the fish, usually twenty to thirty minutes, while the male incubates the eggs.

Sometimes a female will head right back to the nest after feeding, but often she will continue on with her break, preening her feathers at the perch, stretching a leg or wing, and perhaps dropping down to a nearby shoreline to bathe—or even chasing a passing gull or crow.

About thirty-five to forty days after an egg is laid, it begins to hatch. To an observer from a distance, it can be tough to know when this happens. The female

Checking the contents of an Osprey nest in the coastal salt marshes of Massachusetts, USA. In such open habitats, Ospreys readily accept low nesting platforms like these, which allow easy access by researchers.

Ospreys defend their nests against potential predators, even when they do not pose a direct threat. Here, a breeding female chases a passing Brown-necked Raven (*Corvus ruficollis*). Oman.

continues to incubate as she has been doing, although she may stand more often, peering under her belly as if to confirm this change is occurring, or to turn the eggs. But climb to that nest and peer inside, and it is quickly obvious there is new life stirring. Hatching eggs are vocal, faint peeps emerging from inside the shell. Hold such an egg in your hand and you may see small cracks in the large end of the shell, where the chick's head is positioned, and perhaps a hole starting to appear, with a tiny bill inside tapping around its edges. Put such a "pipping" egg to your ear and those peeps sound louder and more insistent. For any keen naturalist with an appreciation for wild animals, few experiences can match this one—the lingering warmth of the egg in your hand, the insistent calls, the wobbling bill of a chick just barely visible inside a widening hole in the shell, the slow but determined emergence of new life.

GROWING THE NESTLINGS

Visit an Osprey nest four or five days after the first egg starts to crack open and you'll find a very different scene than what would have greeted you the week before. In place of solid eggs clustered quietly in the nest cup there will be a small fuzzy bundle of tan-colored bodies, heads wobbling, bills gaping, and a commotion of soft peeps reaching your ear. At this early stage the chicks are unfazed by the appearance of a human torso at the edge of their nest, even though their parents circle overhead calling in alarm. In fact, the chicks react to your movement with much the same behavior they'd use to greet a parent holding a chunk of fish at the edge of the nest. I often find half-eaten carcasses of fish in nests when I climb to them at this stage and I'm usually unable to resist pulling a few small bits off the carcass and offering them to the young. Maybe it is the eagerness with which they grab that food in their tiny bills, wolfing down each fishy chunk, or maybe it's just a small way of appeasing my guilt at disturbing the nest, but I never fail to take great satisfaction as the interloper parent in providing a little extra nourishment to these young that are so new to the world.

What strikes me particularly at this early stage in the nestling period is the variation in chick development. I'm often able to visit twenty to thirty nests in a day, given the density of nests in the region I study, and an average of two to three chicks in each nest allows me to view a remarkable spectrum of variation in a short period of time. Heading home at the end of one of these productive days, and thinking over what I've seen, a few things stick in my mind. First, some nests are considerably more advanced than others, with many pairs still incubating eggs while others have young two or three weeks old. Yet even looking only at broods with chicks in their first week of life, there are subtle but important differences among nests. Some have chicks of roughly equal age; they look nearly identical and, measuring their bills (bill length correlates nicely with age in Osprey young), I see that they all hatched on about the same day. The female may

A male Osprey delivers a flounder to his mate and young at the nest. At most nests, male parents provide all of the food their family consumes while the young are growing. At a few nests females contribute as well, especially when the young are older. Connecticut, USA.

have delayed incubation until she completed the clutch, or the young somehow coordinated their hatch to emerge on the same day (this is known to happen in waterfowl, via vocalizations within the eggs).

For Ospreys, we don't know how this might happen. At most nests, however, about two-thirds of them, the chicks are much farther apart in age—four to five days or more—with young from third- and fourth-laid eggs much smaller than their older siblings. These runts are at a big disadvantage as broods mature, especially when food is scarce at the nest. Two to three times as many runts die before fledging as do their older nest mates, or young in more even-aged broods. These early-season glimpses into nests provide a fascinating preview of what can be expected to happen as the season progresses, as young develop from tiny hatchlings into fully feathered Ospreys.

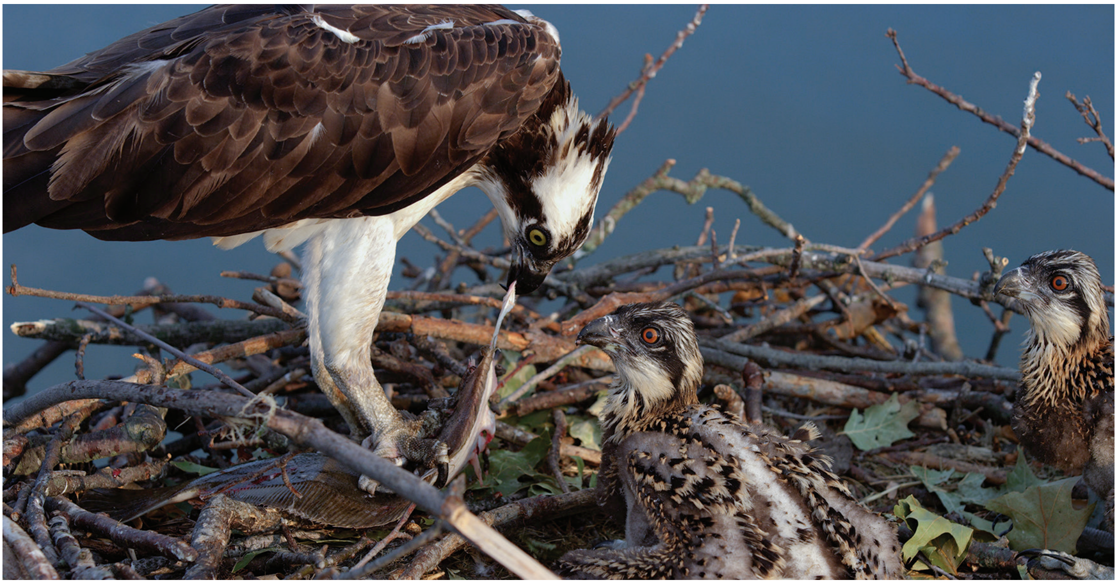
And grow they do, remarkably quickly. At hatching an Osprey chick weighs just fifty grams (one-tenth of a pound), about the same as a small pair of eyeglasses or two or three cherry tomatoes—2.5% of what a full-grown female Osprey is likely to weigh. Held in your hand the chick's weight would barely register. Instead you'd be more likely to focus on its remarkably fuzzy appearance, clothed as it is in its downy tan plumage. This down is actually made up of feathers, but simple unbranched feathers—an almost furlike covering that helps the chick retain warmth. You might also notice the beak and claws of this new hatchling, the claws so small and undeveloped it is hard to believe they will grow into formidable weapons able to snatch thousands of fish in a lifetime. The bill, dark with a white tip, seems poised to take in food, as it does quite readily, although it is still far from ready to rip into a fish. That white tip is the "egg tooth," the key to its release—a hardened portion of the upper mandible that helps the chick peck its way through the eggshell. It will soon slough off as the beak grows.

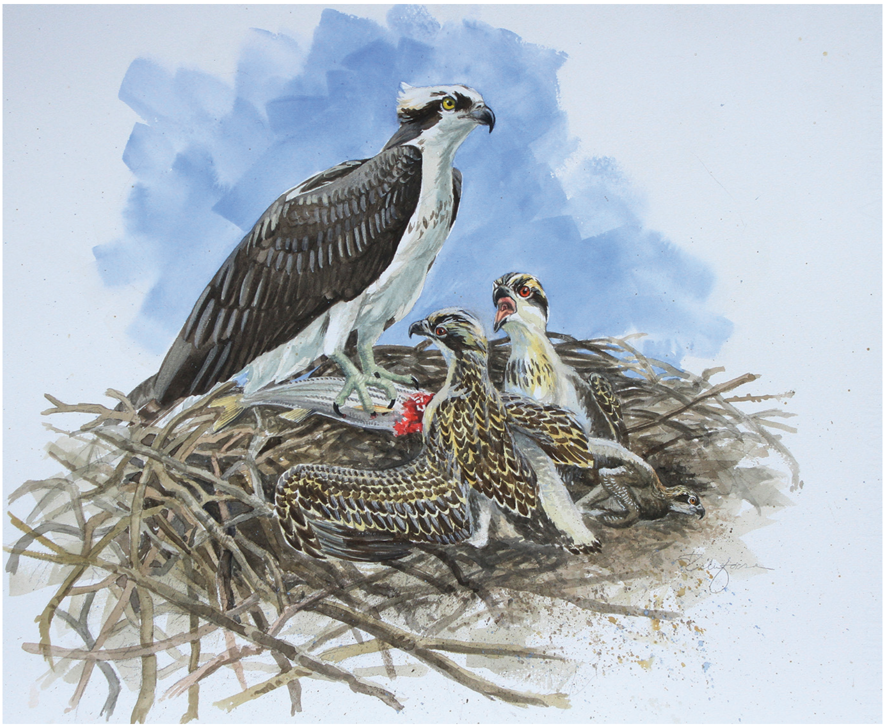
Osprey hatchlings are known as "semi-precocial," which means they are a step back in development from the precocial young of chickens or ducks—young that can scamper after their mother just a half-day after emerging from the egg, and feed on their own. However, Osprey hatchlings are a step ahead of the altricial young of songbirds, which are born largely naked and barely able to move much of anything beyond their heads and necks to beg for food. Osprey chicks stay in the nest, but have increasing mobility in it, which is an asset when trying to reach a parent that is distributing food.

Young Ospreys depend on parents for warmth and food. Food fuels their growth, generates the body heat that keeps them warm, and ultimately dictates whether they live or die. Many do die, unable to compete for limited resources. It all depends on the parents, particularly the male parent's ability to find fish.

Parental behavior shifts after their young hatch. The male continues to provide all the food and to deliver each fish to the nest, usually after eating his share, but now the female stays at the nest after the male delivers and sets herself up to begin ripping that fish apart and presenting small bits to the young. With very small young the female can be remarkably deliberate and gentle about this, taking each tiny piece of fish in her bill and slowly lowering it toward the wobbling head and gaping bill of whichever chick is begging hardest. Once that bit is released into a gaping beak, the female is right back at it, ripping the next piece away

Nestling Ospreys are fed by the female parent at the nest, after the male parent delivers a fish. Females rip the fish apart and present it in small bits to their young. Connecticut, USA.





When food is scarce, Osprey chicks often fight for dominance in the nest. Older, larger young have an advantage in this, controlling access to the female parent distributing food. Long-term survival of younger chicks can be jeopardized in these situations. The female parent does not interfere in these circumstances; instead, she feeds whichever begging chick is closest.

from the fish carcass and following up with the same rhythm: rip, twist, tear; lower morsel to gaping beak; back to fish.

When a piece is too large for the young, or when the young are satiated and stop begging, the female takes some bites for herself. But the young generally come first and, if begging, it's rare a female will feed herself ahead of them. Once the chicks are full and stop begging, any remaining fish is hers, and she can work her way through one briskly. She sometimes even eats the tail at this stage, struggling to gulp it down. When I weigh females at the end of the season, using electronic scales at their perches so I don't disturb them, I find these birds have lost at least 10%–15% of their body mass during the nestling period, while their mates, the foraging males, lose much less. It seems likely that the female parents are hungry much of the time they are raising young, especially as the young get older and take more food.

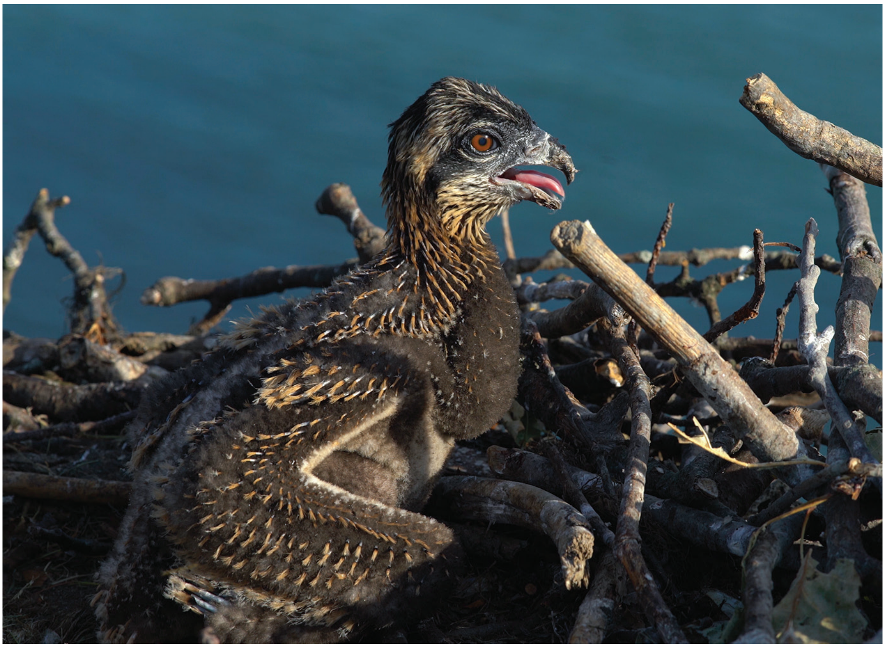
Besides distributing food to their young, females have a crucial role in keeping the chicks warm and protected. Nestling Ospreys cannot regulate their own body temperature until they are two to three weeks old, so they are vulnerable to cold and wet weather. Heavy rainstorms can wreak havoc on small young in nests, especially if those storms go on for more than a day. Checking nests soon after big rains I often find the lining of some nest cups damp or even wet, and the chicks along with it. Interestingly, some nests are drier than others, perhaps owing to how they were built or to how efficiently females were brooding. Wet chicks are far more likely to die; a severe rainstorm can kill 20%–30% of the chicks in the colony I study in just two or three days, and it is the wet chicks that go first. Much of this loss hinges on whether a male can deliver fish in such challenging weather, but it seems that nest construction and female brooding may play a role as well.

Delivery of fish by male Ospreys doubles and then triples in the first twenty days after the chicks hatch, a critical growth period for nestlings. Not only that, young take an increasingly large share of each fish as they age, from about 20%–40% in their first twenty days of life to about 50%–60% in the fifteen days after that. A male parent with three half-grown young (twenty to thirty days old) has many hungry mouths to provide for: his own, those of his young, and his mate's as well. Males typically spend about 20%–30% of the day foraging when nestlings are taking food at peak demand.

It is interesting to see this variation among males and to wonder why some are more reluctant to head off on foraging trips than others are, and why almost none spend more than about one-third of the day foraging. It seems there are real energetic limits here, with males hitting a point in their energy balance that cannot be surpassed without jeopardizing their long-term viability. Some females do fish once the young are a few weeks old, but this is rare in most regions and not without risk, as they are the key defenders of the nest.

While human parents often remark at how quickly their own children grow, the growth of young birds is truly extraordinary. As author and artist-naturalist Julie Zickefoose, a devoted student of baby birds, has put it, "as much as I

As parents, female Ospreys show great care in feeding small chicks in the nest. Small bits of fish are presented with great delicacy. Connecticut, USA.

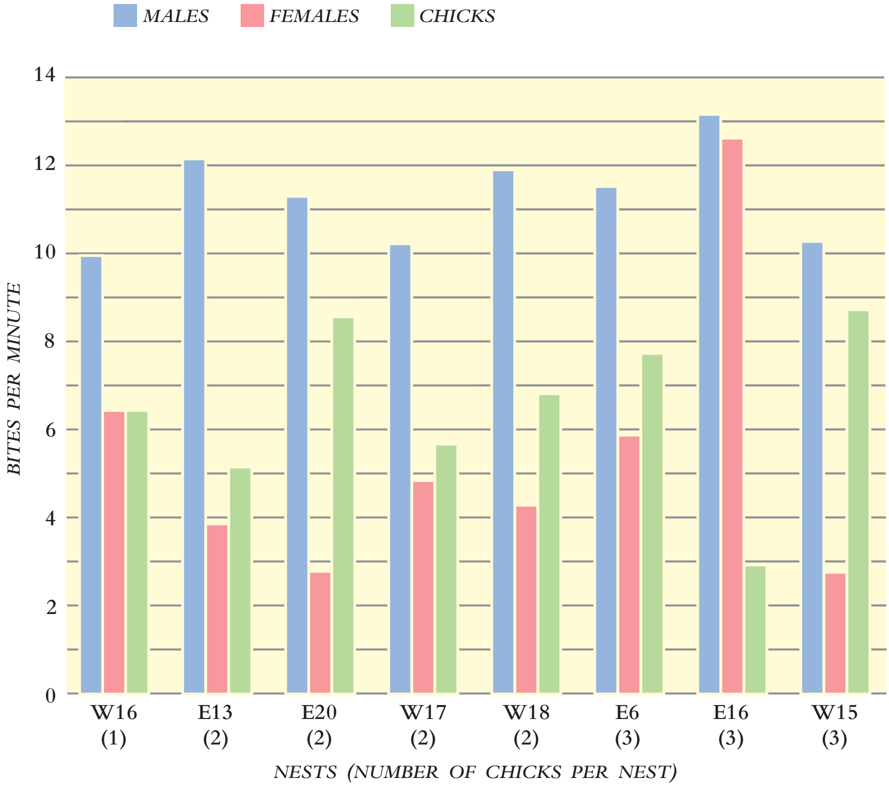


Osprey nestling in its so-called "reptilian phase," at about 20 days of age. At this stage it has molted the paler coat of feather down it hatched with, replacing that with the darker down seen here. Note the first full feathers emerging as well as the extended sac of skin on its neck—a crop for storing food. Connecticut, USA.

have witnessed it, the transformation of a nestling each twenty-four hours is still the most astonishing yet underappreciated phenomenon I know of." There is intense selective pressure to get out of the nest and on the wing quickly, both to escape predators and to prepare for migration. While Ospreys do not break any records in growth (larger species of birds tend to grow more slowly than small ones), they still condense a lot of change into very little time. Osprey chicks triple their body weight in the first eight days they are out of the egg, and then double it again in the next four days. During the period of fastest growth, between the ages of fifteen to thirty days, chicks are gaining an average of forty grams (0.09 pounds) a day, about 2%–3% of their final weight. If your child grew at an equivalent rate, they'd be putting on about four to five pounds (1.8–2.2 kg) a day, surely an alarming thought to any parent! By thirty days of age, Osprey chicks have achieved 70%–80% of their total body mass and growth slows; more energy starts to flow into feathers at this point, preparing the birds for flight. So in the first two-thirds of the growth period bone has priority over feathers, only to have this reverse in the last third.

While hatchlings retain a light coat of down for ten to twelve days, a darker, woolier down then replaces it. During this transitional period the birds look, to me, distinctly reptilian (dark and scaly), hinting at their primeval ancestors. A week or so later, feathers start to appear, first on the body (rusty-gold pinfeathers on head and neck) and then later on the rest of the body and on the wings and tail. This is an amazing process, with the feathers getting their start in prominent blood quills (feathers need blood to grow), which disintegrate and are shed as the

A female Osprey guards her brood of rapidly growing young, about 35 days old, along the edge of a Connecticut estuary. Note how eye color differs between adults and young.



Rates of feeding (as measured in bites of food consumed) at eight Osprey nests with young in Massachusetts, USA. By watching feeding Ospreys with a telescope, researchers can get a fairly accurate picture of how a fish is divided at the nest. Note that most male parents took more of each fish than their mates or young and that chicks often (but not always) got more than the female parent.

As nestling Ospreys approach fledging (first flight), they spend time exercising their wings. These young, about 50 days of age, will probably be flying in a week or less. Western Australia.

feathers push out of their sheaths. Handling young at this stage often results in a minor blizzard of sheath bits fluttering off the bird, like dandruff in humans, reminding one how fast the feathers are growing. Last to emerge are the flight feathers, both for the wings (primaries and secondaries) and for the tail (rectrices). These are the largest feathers and take the longest to grow. Once those feathers are fully formed, the fledglings are ready to take to the air.

GAINING INDEPENDENCE

As the young near the age of fledging (their first flight), they begin to exercise their wings vigorously, creating a blur of wing flapping when seen from a distance. Sometimes they take turns doing this, one seeming to inspire the next. They soon begin to flap vigorously enough that they lift off the nest, bouncing and jumping as they pump their wings, close but not yet ready to launch into full flight. By this time the female parent usually moves away from the nest, finding a perch near enough to be able to watch and defend her young, but distant enough to avoid the chaos of begging and wing flapping. Human mothers with a houseful of rowdy teenagers might be in sympathy here.

The young are now able to feed on their own, without their mother as intermediary, so when fish are delivered the birds pounce on them. They beg often; a chorus of begging calls emerges from Osprey nests at this time of year. The male parent must become inured to this as feeding rates often drop just before the young fledge, perhaps a stimulus that nudges them into flight.

Somewhere between the ages of fifty and sixty days Ospreys take to the air. Young in nonmigratory populations and those with less food seem to delay the longest. First flights can be surprisingly competent, although subsequent landings are often awkward. As any human pilot will tell you—flying is easy, it's the landings that are tough. But the birds soon develop flying and landing proficiency; even though they seem to flap a little more rapidly than adults do, they are very much Ospreys on the wing after a week or two.

Catching fish is an even more challenging part of an Osprey's coming-of-age. We know from studies of first-year young on their wintering grounds that these birds continue to lag behind adults in foraging efficiency during their first fall and winter, although by the following spring their skills are close to equivalent. The key element is that each Osprey has to learn to fish on its own; parents don't teach them.

For at least a month after fledging, the nest remains the center of a young Osprey's life, for it is there that it continues to receive food from the male parent—consider this an allowance of sorts. In migratory populations female parents generally head off on their own soon after their young fledge, often finding nearby feeding grounds where they begin to regain the weight they have lost during the nestling period. But the male stays on, and his role is critical in bringing fledgling Ospreys to independence. While the young are learning to fish, they are rarely catching enough to maintain the body condition they need to complete a migration. The male parent makes up this difference. This is a poorly documented period of the Osprey's life, and there is much that we still don't know about it, but we can be certain that some males will be better providers than others and that those differences help determine the survival of the young after they launch out on their own.

Watching Osprey nests in this season, as the young get ready to leave, a few thoughts come to mind. One is that this family group, the male parent and the two or three offspring he is helping to nourish, will likely never see each other again. We know from satellite tracking that the wintering grounds of siblings are scattered all over the map, and we know from banding that most young return as breeders to areas fairly near their natal site—although usually at least dozens of miles away, and sometimes much more. There are a handful of records of offspring breeding with one of their parents a few years after returning, so it is not impossible to have siblings reunited, but the chances of this happening are slim.

There is another thing to think about here: nutrition. Adequate body condition is key to surviving migration, so it would be helpful to know in more detail how these young are faring. Anecdotal evidence (from occasional autopsies) suggests that many are laying on fat—probably a key element helping these young birds complete their first migrations.

As we have seen, life at the nest is a well-studied part of the Osprey's year, and finding and holding a nest are critical to launching these birds into successful breeding. Producing eggs and growing young is a joint venture, with the male parent contributing most of the food and the female tending more to the nest. Courtship feeding helps stimulate the female into accepting male copulations and producing eggs, which usually hatch over a period of four to five days. The young grow quickly, spending the first two-thirds of their fifty to fifty-five–day nestling period accumulating body mass and the last third growing the feathers that will launch them into flight.

Attachment to the nest fades as the young begin to forage for themselves and reach independence. Although they often return to the nest for feedings, older fledglings increasingly disperse to nearby perches to feed, and begin to wander and explore their surroundings. It is likely that this exploratory period helps lock in key aspects of their natal grounds, both visual landmarks and perhaps geomagnetic coordinates as well, which they will use to help guide their migrations.

SIX

On the Wing

Incredible Journeys

Late summer brings a noticeable turn in the weather along the coast of southern New England, with shorter days, cooler nights, and a growing sense that autumn is approaching. Waters are still warm and fish plentiful, but while a few weeks earlier our marshes were full of the calls of begging Ospreys, by early September those start to fade. Gradually the nests empty out, one by one, and we remain behind, another summer gone. Compared with the excitement of spring arrivals, this slow stage exit goes almost unnoticed. “Not seeing many Ospreys,” I hear from neighbors who pay attention to such things; “I guess they must be gone.”

And gone they are. With only slightly different timing, this scenario is played out over much of the northern hemisphere where Ospreys are found: Finnish forests and Scottish lochs, Canadian lakes and Oregon rivers, Japanese islands and Chesapeake marshes—out of all these regions and more issue broad braided rivers of migrating Ospreys, each bird heading out on its own, flying alone. Collectively there are tens of thousands of them, pouring south across the continents of Europe and North America, with a smaller flow from central and eastern Asia. Those of us left behind, waiting for another spring to bring Ospreys back, can only wonder where they are going and how they get there.

These birds are launched on extraordinary journeys. One hundred years ago we had only vague ideas where our Ospreys were headed. Even fifty years ago the picture was dim. Today, significant breakthroughs in technology have given us details of Ospreys on the wing—hour-to-hour, sometimes minute-by-minute details that no one could have imagined before the invention of computer chips. Strapping a small GPS transmitter to the back of an Osprey, a transmitter able to communicate with a satellite that relays precise location information back to us, would have seemed like science fiction fifty years ago. Today dozens of Ospreys are tracked that way each year, providing an intimate look at their travels—where they go, if and when they die, what habitats they depend on, and how their lives intersect with humans who may not view them as favorably as we do.

It is hard to overstate what a “game-changer” satellite-tracking technology has been. Before this, researchers relied on information from metal leg bands (rings), most of which were attached to young Ospreys before they fledged. People finding such bands, almost always on a dead bird, would report the band number to a central banding office, and that number became the key to the origin and identity of that bird. Over years those data accumulated, allowing researchers to sketch a rough picture of where Ospreys went in winter and what routes they used to get there. Tens of thousands of these birds were banded over the past fifty to seventy years, mostly in Finland, Scandinavia, and eastern North America, where nests were accessible, populations robust, and researchers committed.

But while analysis of band recoveries made a helpful start on illuminating patterns of Osprey migration, there were inherent biases in the data. Banded Ospreys dying in remote locations are rarely found, while even in more populated regions people finding bands often don’t report them. In less developed countries, the simple cost of a postage stamp or lack of access to the internet can keep a person from filing a report. In other areas, recoveries were reported but the data were misleading. In parts of Colombia (South America), for example, where wildlife received little protection until recently, fish farmers shot and trapped Ospreys for decades and enthusiastically reported the bands (some expecting a reward!). This led researchers, myself included, to conclude that Colombia was a primary wintering ground for North American Ospreys, while in fact we now know—thanks to satellite-tracking data—that the species winters broadly across much of northern South America, with Colombia no more central to wintering birds than any other region. With his typical wry humor, UK ornithologist Tim Birkhead summed up the challenges of using band returns to determine bird migration patterns: it is, he writes, like trying to determine the summer holiday locations of British tourists by noting the locations of police stations where lost passports were turned in.

That said, decades of data from band returns, together with the more recent flow of information from individuals tagged with satellite transmitters, have given us a clearer picture of Osprey migration patterns than is available for nearly any other bird on the planet. The broad patterns are now well established: about 90% of the world’s Ospreys are migrants, all coming out of Northern Hemisphere breeding populations. Winter finds most of these birds either in West Africa (western European nesters) or the northern half of South America (eastern North American nesters), with Mexico and Central America holding many of the migrants from western North America.

While seemingly routine for the Ospreys, the journeys to reach these destinations are remarkable by any measure. On average, these birds are flying at least 2,500–3,500 miles (4,000–5,600 km) in four to five weeks. Nearly all of western Europe’s Ospreys cross some portion of the Mediterranean Sea and the Sahara

Rob Bierregaard

OSPREYS IN THE AGE OF SILICON

Many researchers have helped to pioneer the use of satellite transmitters to track Ospreys in migration and in their day-to-day lives on breeding and wintering grounds, but no one has done more than Rob Bierregaard to modify and perfect the techniques and to get people excited about what can be learned from moving Ospreys into the "Age of Silicon." Rob coined this term, referring of course to the silicon chips that power our computing devices, including the transmitters that Ospreys wear and the satellites that help track them.

Rob began studying birds of prey on the US island of Martha's Vineyard, Massachusetts, in 1971, when Osprey numbers there had dwindled to just a

Desert; American Ospreys cover similar distances in roughly the same amount of time, spending at least one to two days crossing the Caribbean Sea, nonstop, or working their way south through arid landscapes to Mexico and Central America. Only in Japan and eastern Asia does Osprey migration remain a mystery, with most breeders there likely headed into Southeast Asia or the Philippines. Japanese Ospreys are ripe for studies with satellite transmitters.

We are starting to know a lot more about how Ospreys complete these epic journeys. Food is key, especially as individuals traverse long distances over inhospitable, fishless landscapes. It turns out that Ospreys have a well-developed capacity to fast, often going days without food or water. Fat is a crucial resource.

handful of pairs. As a young student at Yale University, Rob helped monitor the Vineyard Ospreys in their initial recovery from pesticides, before he moved on to graduate work at the University of Pennsylvania and a museum-based project on niche separation in global birds of prey. From there, Rob migrated to the Amazon where he managed a large, complex project focused on tropical forest ecosystems. More than a decade in that posting exposed him to a lot of extraordinary birds, including a splendid array of forest raptors, but Rob never forgot his early love for Ospreys and gradually made his way back to them when he returned to the United States in the late 1980s.

By 2000, Rob had begun collaborating with others using transmitters to track Ospreys, and he branched out on his own a few years later, focusing on the migrations of US nesting populations in northeastern and mid-Atlantic states. Since then, he has deployed transmitters on almost a hundred Ospreys, both adults and juveniles, raising considerable money to make that happen and moving ahead with new technologies as they developed.

Perhaps most importantly, Rob has made his data accessible to the world. His website OspreyTrax.com is a reflection of Rob's engaging personality—full of humorous quips and asides, and with interesting maps and bios on all his birds. Overall it is a model for how to present natural history information to bird enthusiasts. His Ospreys come alive on those pages; one follows their progress with a sense of anticipation we usually reserve for traveling friends or family, and maybe even more!

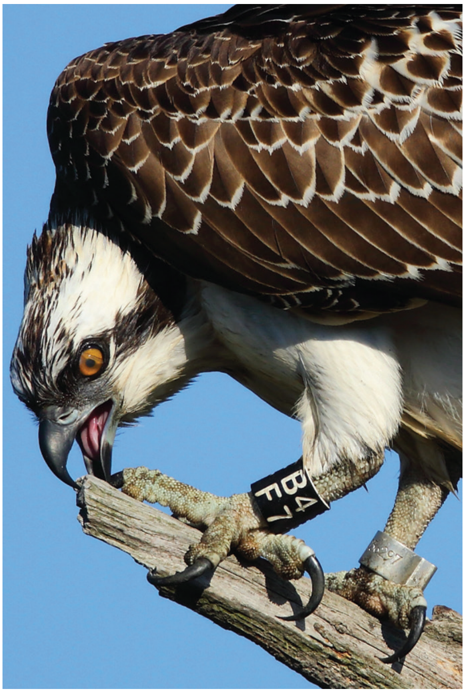
Rob continues to refine his approach, and we see his creativity continue in some of his most recent work—for example, a children's book on Osprey migration (*Belle's Journey*), compelling in its detailed story; and the tracking of Newfoundland Ospreys, whose migrations often include large portions of the Atlantic Ocean south and west of that province. Rob's fascination with over-ocean migration led him to crowdsource researchers to help mine the vast troves of data his GPS-tagged Ospreys had given him. Experts from New Zealand quickly arrived on his virtual doorstep, providing sophisticated analyses and some of the first clues about how Ospreys might use the earth's magnetic fields in their long journeys.

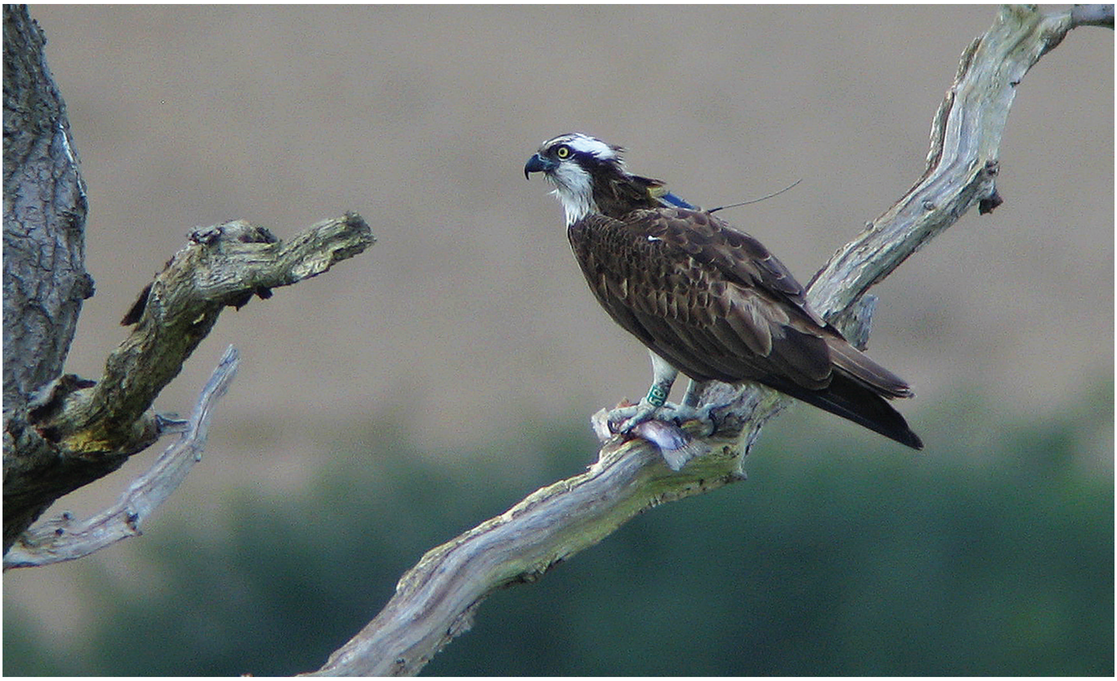
Overall, thanks to Rob and a handful of researchers that went before him, we now know more about the daily movements of North American Ospreys and the habitats that support them—from breeding to migration to wintering grounds—than we do about nearly any other bird on the planet.

Humans, especially those of us in developed countries where our next meal is rarely a worry, tend to scorn fat, but for animals covering long distances with little food available along the way, fat is the fuel that makes it all possible. In addition to providing energy for working muscle, fat releases significant amounts of water when metabolized, so an Osprey traversing deserts or oceans can maintain productive flight even though it hasn't had a bite of fish or a drop of water. Birds that lack fat are probably forced to break up their migrations with longer and more frequent stops, slowing their journeys.

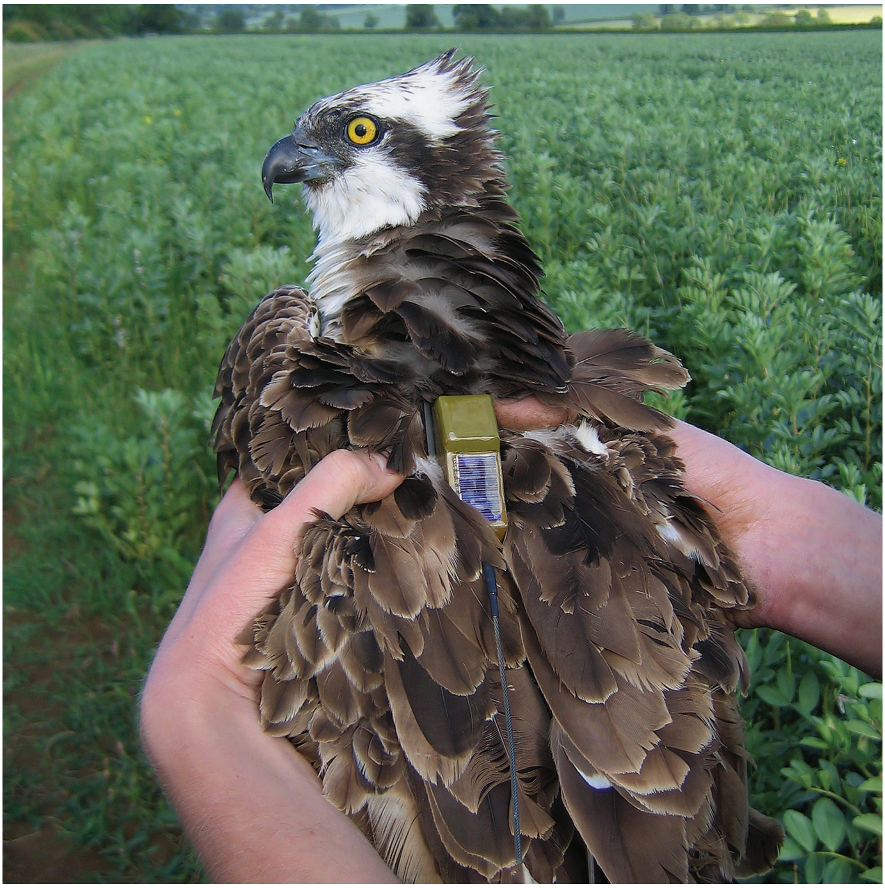
There appears to be another secret to efficient migrations by Ospreys: keen memory. Individual birds discover productive fishing spots along their routes.

Leg bands (rings) help researchers identify individual Ospreys. The large colored band on the left leg of this juvenile German Osprey has a number-letter combination that is unique to this bird and can be read at a distance with a telescope or captured using a digital camera with a powerful lens. In addition, only German Ospreys have leg bands of this color.



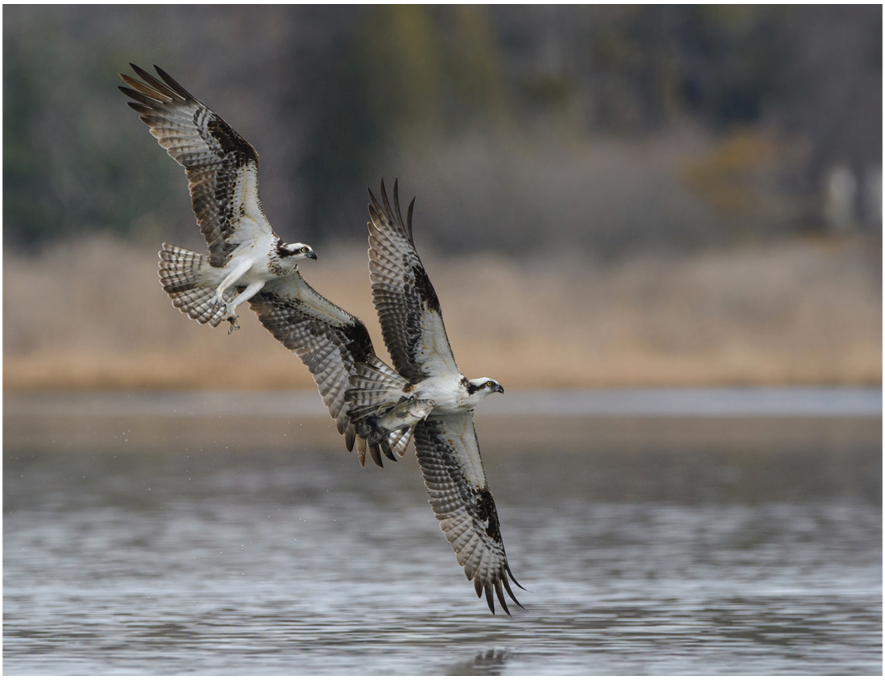


An adult female Scottish Osprey, photographed in central England during fall migration. Note the green leg band with its unique letter/number code that allows researchers to identify this bird, as well as the satellite transmitter (with short antenna) on her back. Eighteen days after this photo was taken, satellite-tracking data showed this bird had arrived in southern Spain, where she spent the winter.



Adult male Osprey "09" from Rutland, England, was trapped at his nest and fitted with the solar-powered satellite transmitter seen here. This bird died while crossing the Sahara, probably killed by an eagle owl (*Bubo bubo*) while it roosted at night on the ground. Incredibly, the transmitter kept producing signals and was eventually tracked down and recovered along with the carcass.

Ospreys sometimes carry fish when migrating, "packing lunch," as some like to put it. This helps ensure they have food in areas where fishable waters may be scarce. Connecticut, USA.



Migratory Ospreys sometime gather at productive feeding locations. When they do, there can be conflicts over fish. Here we see two adult females in Connecticut, USA, one trying to snatch a fish from the other.

Following the paths of satellite-tracked birds, we see many of them return year after year to the same locations along their routes, often taking detours to reach them. Like salmon homing to their natal streams, Ospreys home not just to their nests and wintering locations but also to key feeding grounds along their migration routes as well.

PIONEERS VERSUS STAY-AT-HOMES: WHY MIGRATE?

Not all Ospreys migrate. About 10% of the world's Osprey population consists of individuals that either remain at their nests after breeding or travel just a short distance away. Not surprisingly, these resident birds live where waters remain warm most of the year and fish stay available. Australia, the Red Sea and Arabian Gulf, the Caribbean, Baja Mexico and the Gulf of California, and the Cape Verde and other Atlantic islands are lower latitude regions where Ospreys can be found year round and where nests that remain empty for more than a few weeks are a rarity. Even the Mediterranean keeps many of its Ospreys in winter, although those on its chillier northern fringe (Corsica and northern Italy) spend four or five months in warmer climates such as southern Spain or Morocco.

Florida, in the southeastern United States, provides an interesting contrast between Ospreys that migrate and those that do not. Satellite-tracking data have shown us that all but southernmost Florida breeders are migratory, heading off to South America from August to early winter, with only saltwater nesters on southern Gulf and Atlantic coasts staying behind during this nonbreeding period. Inland, nests on freshwater lakes are largely empty in fall and early winter. Colder weather there drives fish to deeper water; lakes are not buffered from cold the way ocean waters are, so habitat, rather than just latitude, shapes Osprey migratory behavior there.

Looking out my window at New England landscapes on a cold and blustery January day, it seems obvious why Ospreys have left. Ice covers nearby waters and frigid winds blow hard. No Osprey could survive there more than a few days. Despite the northern origins of this species, the Osprey has evolved to be more at home in warmer climates, although it is able to use its considerable migratory abilities to move north into productive habitats in spring and summer. Few Ospreys experience freezing temperatures for more than a week or two each year, and generally only those at higher latitudes at the start of nesting. Globally, the species is migratory north of about 32°N in western North America (roughly the US-Mexico border), 28°N in eastern North America (south Florida), and 38°–40°N in Europe (the northern Mediterranean, central Spain), with variation among these regions reflecting local differences in climate.

On a more immediate level, it is tougher to know exactly what cues urge an Osprey to start its marathon journeys, although we can say with certainty that neither cold nor hunger are involved. Most northern Ospreys leave nests in late summer or early fall, when temperatures are still mild and fish remain plentiful. Likewise Ospreys wintering at tropical latitudes are unlikely to find anything in their environment that would trigger a return migration in spring. Why, we might ask, leave a benign tropical environment for icy, thawing waters at northern latitudes? In the tropics day length is uniform, fish are available year-round, and temperatures are as warm as an Osprey is likely to experience at any point in its annual cycle. So there appears to be nothing in the environment to tell the birds when to leave.

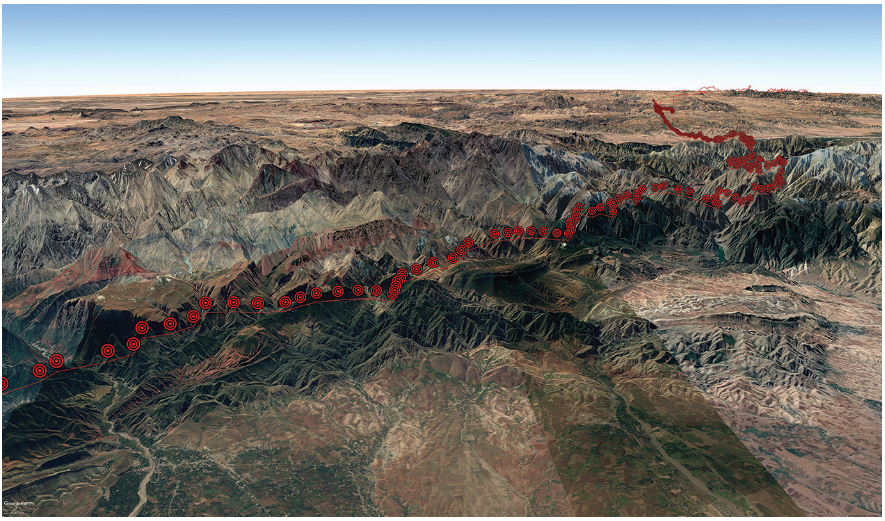
Instead it must be internal cues that are setting the birds on their way—shifts in the subtle flow of hormones through their bodies that, we know from studies of other birds, determine the degree of migratory restlessness that each individual bird experiences. But how these flows are regulated, how the timing is set and kept on track, remains unknown for Ospreys, although it seems likely that regular seasonal shifts in day length on breeding grounds play a role in resetting their internal clock each year.

EUROPE: TRADING NORTHERN LAKES FOR AFRICAN RIVERS AND BEACHES

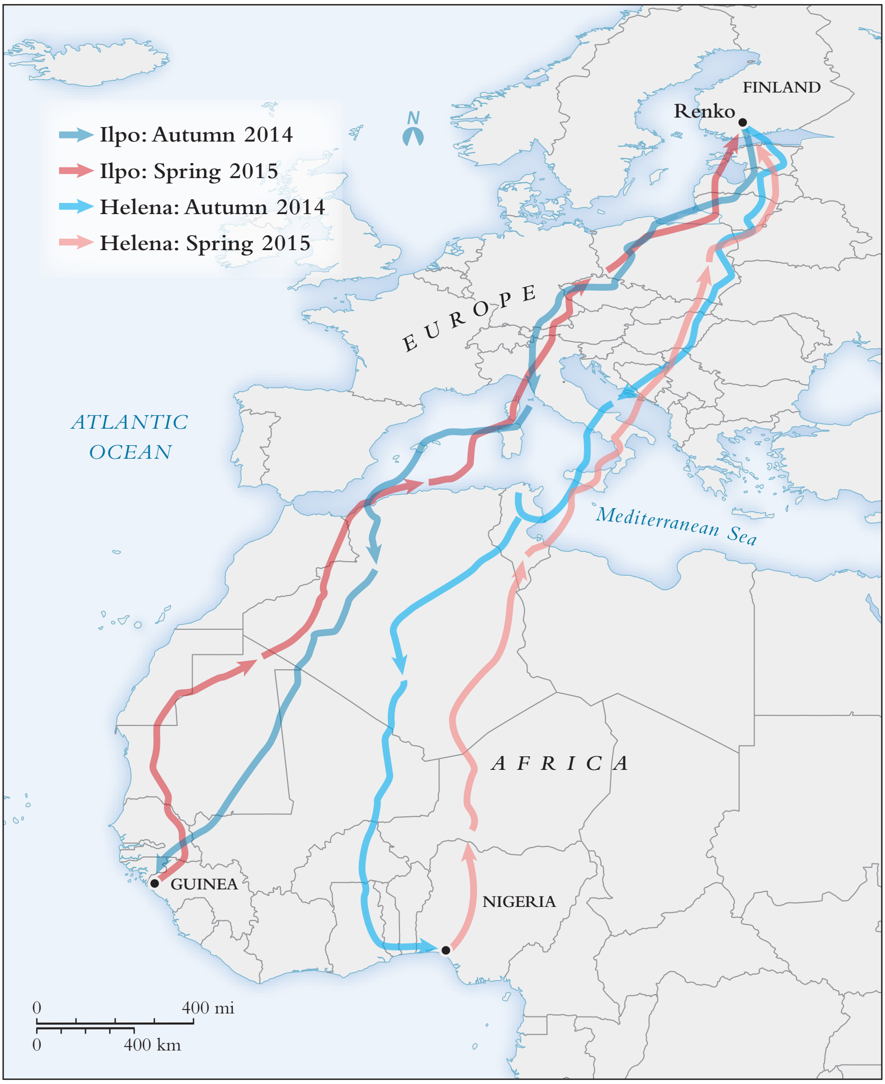
Starting in the last few weeks of August, Ospreys, along with millions of other migrant birds, begin to empty out of the forests of northern Europe. This broad, braided, south-flowing river of life has its origin, at least for Ospreys, in the extensive boreal spruce, pine, and birch forests of Sweden, Finland, and western Russia, where over 90% of Europe's Ospreys breed. An observer fortunate enough to spend August and early September at Falsterbo, an idyllic stretch of seacoast beaches and marshes at the southwestern tip of Sweden, would catch a glimpse of that Osprey river passing overhead. It would begin as a trickle in the first week or two, then swell to dozens of birds a day by the last ten days of August, tapering off to a few stragglers by the second and third week of September. Farther south, at hawk-watch points like Gibraltar in southern Spain, or Sicily and Malta in the Mediterranean, that same flow would pass through a week or two later, en route to the warmth and fish-rich waters of western and central Africa.

The farther east one moves across Europe, the more likely it is that Ospreys fly an easterly route on their migrations, with many of these birds passing through Greece or Turkey on their way across or around the Mediterranean. But little is known about how Russian and other Eastern European Ospreys actually migrate (few have been banded or tagged there), so we focus on Ospreys from western Europe—especially Sweden, Finland, the United Kingdom, and Germany—where extensive banding and use of satellite transmitters have opened a flood of new information in the last two decades.

As they leave their nests and head out across Europe, Ospreys move southwest on a broad front, funneling into more constricted routes when crossing the Mediterranean, the first major barrier they encounter. There, they take advantage of land bridges that make overwater passage less challenging: southern Spain, where Morocco is a short flight away; Italy and Sicily, where the island of Malta



The Sahara Desert presents a formidable barrier to European Ospreys migrating to and from West African wintering grounds. Most of these migrants need at least four or five days to make the crossing. The track shown here in red covers about an hour in the trans-Sahara flight of a male Scottish Osprey, "Blue XD," on his second migration south. Note how, on this leg of its migration, the bird avoids the highest peaks of the Atlas Mountains, instead working its way along lower hills and through valleys.


Ilpo: Autumn 2014
Ilpo: Spring 2015
Helena: Autumn 2014
Helena: Spring 2015
N
FINLAND
Renko
EUROPE
ATLANTIC OCEAN
Mediterranean Sea
AFRICA
GUINEA
NIGERIA
0
400 mi
0
400 km

Fall and spring migration routes of a mated pair of Finnish Ospreys (Ilpo and Helena), as shown by satellite-tracking data. Note three things: these birds fly separate routes after leaving their nest and winter far apart, as is typical for mated Ospreys; for each bird, spring and fall routes differ somewhat, especially in Africa; each bird takes advantage of land bridges (Italy, Sicily, Corsica) for crossing the Mediterranean Sea, as do most Ospreys migrating from western Europe.

provides a final stepping-stone to North Africa; and the larger islands of Corsica and Sardinia, an alternate route south that parallels Italy. Clearly, if there is a mantra for migrating Ospreys, it is this: stay over land where possible to shorten overwater flights; and where such bridges are missing, try to avoid bad weather and cross anyway.

Let's pause briefly to consider the choices a migrating Osprey must make when confronting a vast expanse of water. We can never really know how Ospreys make such decisions, but we can see that many individuals tracked by satellite show no hesitation when leaving land for open ocean—no change in speed and none in tracking. Some stop, occasionally making a few false starts before committing to the trackless wastes. However Ospreys decide about crossing seas, the human observer standing on those same shores and looking at those same limitless horizons cannot help but be moved by the enormity of what these birds confront. And yet for tens of thousands of years Ospreys have made these crossings routinely every fall and spring.

Among Europe's Ospreys moving south, a few individuals linger on to winter in southern Spain, especially breeding males from Germany and the UK, but at least 95% of these birds keep moving after crossing the Mediterranean. Surprisingly few winter along the coast of North Africa. Instead, faced with over 1,000 miles (1,600 km) of barren, fishless Sahara Desert, the birds improbably head out into it, a minimum passage of four to five days south and west. Among the many challenges the birds face are frequent and sometimes violent dust storms, which can blow up in minutes; searing heat (up to 130°F [55°C] during the day); and high mountains (the Atlas, with peaks to 13,000 feet [4,000 m]). Ospreys have no choice but to fly and to fast—going without food for days. Body reserves likely power these marathon journeys, and the birds avoid the highest areas by tracking though mountain passes or by seeking out lower stretches of hills for crossings. To their advantage, they can land in the desert when they need to, resting on rocks and pinnacles at night, and can even backtrack if they run into a dust storm or lose their way. Data from GPS-tagged birds show they often soar on thermals, saving energy as they work south. If Ospreys could dream as they head across the vast arid wasteland of the Sahara day after day, surely they are dreaming of water and fish.

Like all young Ospreys, European juveniles on their first flight south tend to wander more than adults do, often diverted over ocean waters. So it is not unusual for young fledged from nests in Scotland and England and even Scandinavia to end up well west of their home ground—for example, in southern Ireland—after leaving their nests. From Ireland, confronted by open water to the south, they often fly 400–500 miles (650–800 km) out over the Atlantic to the Bay of Biscay, eventually reaching the north or west coasts of Spain, where they resume migration overland through Gibraltar and Morocco to West Africa.

Tracking and banding data show that about one in three juvenile Swedish Ospreys die crossing the Sahara in their first migration south, a significant portion of overall mortality in the first year (which is roughly 50% in Ospreys). Coming up against the barrier of the Atlas Mountains in Morocco, many of these young birds track east or west along that front. Those going west avoid some of the highest peaks and find a fairly direct route south. Those going east end up with a longer trip and more desert to cross, and are more likely to die. Thus a single navigational decision can have very real consequences for these birds.

Adult females, those that have nested and raised young, often take longer migrating south than their mates or young do. In large part, this is because they spend at least a week or two feeding in nearby lakes and rivers after leaving their nest, presumably fattening up and completing molt. Keep in mind that females have to share food with hungry young in the nest for almost two months and are known to lose weight as the young grow and demand an ever-larger share of what the male parent delivers. Females also molt wing and tail feathers during breeding, unlike their mates that have to keep feathers intact in order to maintain peak fishing efficiency. So it is hardly surprising that these drained females need a recharge before they head off for Africa.

Once on the wing and moving steadily south, European females tend to travel at about the same speed as their mates do, on average 130–70 miles (210–75 km) a day. At those speeds and given stopovers for feeding and rest, a Swedish or Finnish Osprey might complete its migration in thirty-eight to forty days, with only twenty-two to twenty-six of those days actually flying. But there is significant variation in migration mode among these birds, probably reflecting the weather they encounter along the way, and who they are—their inherent competence. There seems little doubt that some migrant Ospreys are more motivated than others, better able to fly these long distances quickly and efficiently; nutrition and body condition may play a role in explaining these differences. One satellite-tagged male flew from Sweden to Spain in a single day, a distance of 463 miles (746 km). Another made the trip from southern Sweden to Guinea Bissau, West Africa, in just fourteen days, averaging 267 miles (431 km) per day. At the other end of the spectrum, some juveniles wander for a month or more in Europe before moving on to Africa, and one adult Swedish female took eighty-one days to reach her wintering spot in Mozambique, East Africa, although only thirty-seven of those were spent in actual travel.

Once across the Sahara, Europe's Ospreys emerge onto the Sahel, West Africa's steppe–savannah transition zone between desert and the more forested regions of the coast and Central Africa. There they find vegetation and water—often shallow, seasonally flooded wetlands—arriving as they do after the rainy months of late summer, when these wetlands are most in evidence. Millions of waterfowl and wetland birds from Europe throng flooded regions like the Inner Niger Delta in Mali, which in wet years may be as large as the countries of Belgium or the Netherlands. This, along with the vast reaches of Lake Chad to the west and the Senegal River and lower portions of the Niger River to the east, form a string of wetland oases for fish-hungry Ospreys emerging from the desert. Many, especially juveniles, settle in and try to winter at these spots, although drought often shrinks these wetlands a few months after the birds arrive and sends them wandering in search of better foraging, often south and west to the Atlantic coast.

And it is this coast, the broad ribbon of beaches and mangrove forests and fertile river estuaries that stretch from northern Senegal and southern Mauritania through the Ivory Coast and Ghana, that concentrates wintering Ospreys as few other parts of the world are able to do. At least half of Europe's Ospreys find

Africa to Scotland

THE TRAVELS OF ROTHIEMURCHUS

Fitted with a satellite transmitter as a young fledgling in August 2009, Rothiemurchus (Rothie) was named after the estate on which he hatched in northern Scotland. The land has been owned by the same family, the Grants of Rothiemurchus, for generations, and they have taken an active interest in Osprey conservation going back to the nineteenth century. More recently, the estate continues this tradition by leaving sections of their trout fishery open to Ospreys, catering to photographers looking for close-up shots of the diving birds.

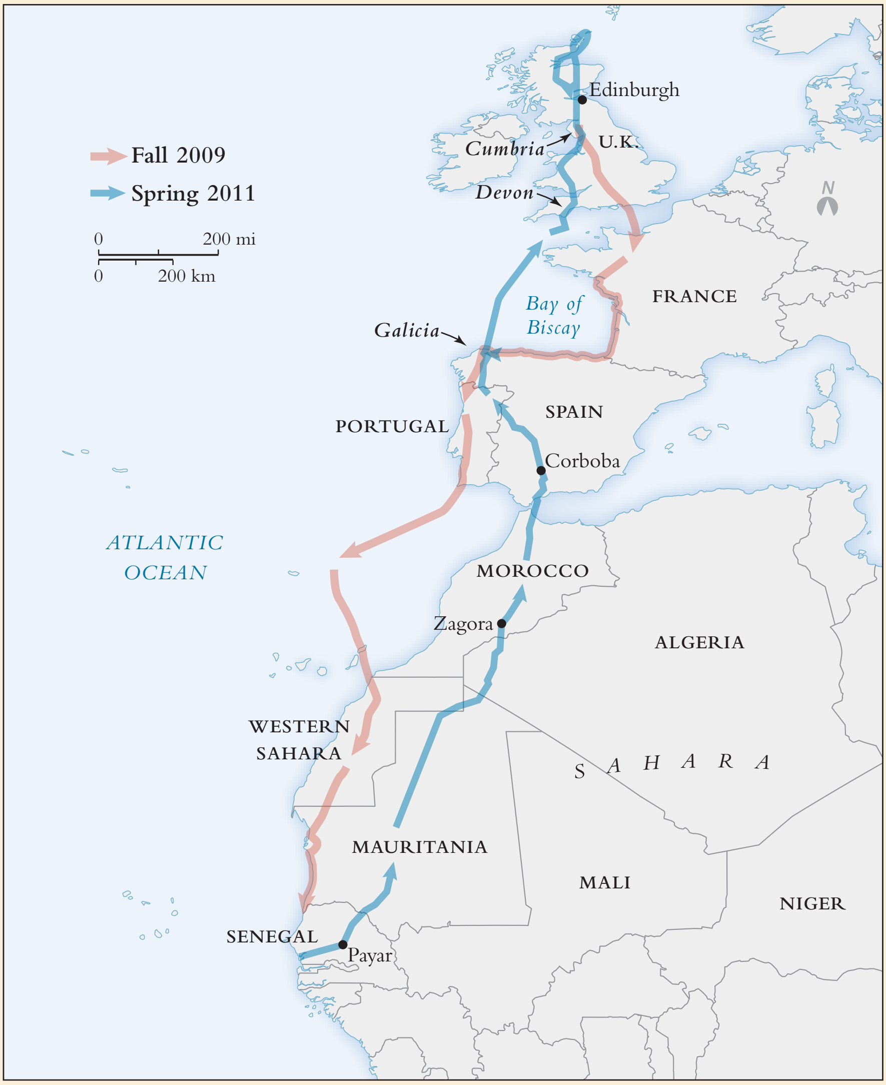
Rothie successfully migrated to Africa and spent the winter and most of the next year along coastal wetlands in northern Senegal (the marshes of Sine Saloum, winter home to many of Europe's Ospreys), with occasional exploratory forays south into nearby Guinea Bissau and the Gambia. Like all young Ospreys spending their first winter in the tropics, he took a "gap year"—didn't begin a return migration until his second spring in the tropics (age one year, ten months), remaining in these same backwaters until May 9, 2011. We pick him up as he sets off on his first migration back to Scotland, giving us a chance to glimpse the extraordinary details revealed by one of the newer GPS transmitters that this bird was wearing. We rely here on the careful notes of Roy Dennis, who caught and tagged this bird, and then followed his progress (virtually) day by day. Abbreviations as follows: GMT (Greenwich Mean Time); mph (miles per hour); kph (kilometers per hour); ft (feet); m (meters); km (kilometers); mi (miles); N, E, S, W (north, east, south, west).

Day 1. Rothie set off on his first migration north at 11:00 GMT, May 9, 2011. His first hour in flight found him easing into migration, traveling fairly slowly NE at 18 mph (29 kph) and at an altitude of 755 ft (230 m). Three to four hours later his speed had increased to 31 mph (50 kph) at an altitude of almost half a mile. Evening found him near the small village of Payar, in central Senegal, having covered a total distance that day of 221 km. He spent the night roosting in a small tree outside Payar.

Day 2–3. Rothie flies NE into Mauritania and the western Sahara, keeping up good speed (up to 41 mph [66 kph]), at altitudes up to 3,340 ft (1,018 m); he is almost certainly soaring on thermals. By dusk 155 mi (249 km) covered, night in bushes in semidesert, southern Mauritania. Next day, sets off N at 09:00 GMT, slowly at first but by 14:00 hours flying NNE at 40 mph (64 kph) at almost 6,000 ft (1830 m); must be riding thermals at this altitude. Continued flying N over desert; at 18:00 he is roosting on a rocky outcrop in the open desert. An impressive 219 mi (353 km) covered this day.

Day 4–6. Gaining speed, a bird on a mission. Flew N well into northern Mauritania, total day's flight of 383 miles (616 km), with speeds averaging about 40 mph (64 kph). On May 14, heads into Morocco, first chance to fish (that's five days without food or water, suggesting a good build-up of body reserves before he started). By 09:00 perched beside a river; stayed until 12:00. Then flew NE and E over parts of the Atlas Mountains, at altitudes of more than 4,380 ft (1,335 m). Night near Zagora, southern Morocco.

Day 7–8. On day 7, flies 226 mi (364 km) north through Morocco. Next day, he crossed the Mediterranean at 17:00 GMT, nearing Spain and flying NW at 38 mph (61 kph), just 50 ft (15 m) above the surface of the sea, as is typical of Ospreys traveling over water. Landing in Spain, Rothie stopped by a small


Fall 2009
Spring 2011
0
200 mi
0
200 km
Edinburgh
U.K.
Cumbria
Devon
Bay of Biscay
FRANCE
Galicia
SPAIN
PORTUGAL
Corboba
ATLANTIC OCEAN
MOROCCO
Zagora
ALGERIA
WESTERN SAHARA
S A H A R A
MAURITANIA
MALI
NIGER
SENEGAL
Payar
N

river north of Estepona and then flew on N to roost south of Cordoba, southern Spain. An impressive 280 mi (452 km) covered this day. Rothie now in Europe.

Day 9–13. N through Spain; by May 21 had reached far northwestern Spain, Galicia, poised to cross the Bay of Biscay. High-pressure weather building from the S, excellent conditions for crossing the Bay of Biscay. But, as befits a 2-year-old Osprey on its first migration north with no nest to hurry back to, Rothie stayed put.

Day 14–21. Lingers in northwestern Spain, near Galicia, moving among various wetlands and roosting in wooded areas.

Day 22–23. Finally launches out over the Bay of Biscay, starting his flight to the southern UK. Next GPS location was at 16:00 GMT when he was 255 km north over the Bay of Biscay, then turned NW and at 17:00 was flying slowly NNE at 14 mph (23 kph), 175 ft (53 m) above the seas, battling headwinds. An hour later he had picked up speed and altitude, and kept this track as he flew about 50 miles (75 km) W of

Africa to Scotland, *continued*

the coast of Brittany, France. Continued to fly on through the night and came ashore at 11:00 on May 30 on the south coast of England—at Hope Cove, South Devon. All told, 516 miles (830 km) over the Atlantic in twenty-eight hours—an amazing flight! From Devon, continued flying E to fish in Slapton Ley at 13:00, then rested in nearby woodlands until 16:00. Spent the night just north of Killerton, by a small river W of the M5 highway.

From there, Rothie flew north to Scotland in three days, flying through Wales, the Lake District, the Scottish Borders, and over Edinburgh and the firths of Forth and Tay to roost in Angus. He had reached Scotland at last, in less than one month! His summer was spent wandering widely in Scotland and northern England, apparently looking for a nest site. By the end of summer he had settled in Cumbria, in northwest England, to which he returned in subsequent summers to nest.

winter homes along the inland wetlands of West Africa, but the birds are more in evidence on the coast, and their lives are better documented there. England's Rutland Water Osprey researchers have tracked some of their transmitter-tagged birds to this region and now organize annual winter trips there for their naturalist volunteers. The picture they paint is of a vibrant, sunlit world, with scorching midday heat and robust flocks of gulls and terns and sandpipers feeding along beaches and resting on sandbars, Ospreys often mixed in among them. And there are wide-open sand beaches, busy with people—women toting large bundles on their heads, fishermen in canoes with nets, and horse carts piled high with fruits and vegetables—as well as mangrove estuaries where river waters mix with the Atlantic, producing a web of marine life that Ospreys thrive on. Enormous logs wash up on these beaches, some of them roosting sites for small flocks of Ospreys.

This coast is an Osprey mecca. Fish are varied and abundant there, and when they become scarce in one habitat, other areas nearby often remain productive. The mix of salt and fresh waters, river and ocean, helps make these ecosystems especially fertile, and the extensive mangrove forests that line the river deltas provide roosting and feeding perches that Ospreys gravitate to. Energetically it is an easy life for an Osprey: catch a fish or two a day, flying perhaps a mile or two to find them; perch quietly on beaches or in the mangroves for at least 90% of the twelve-hour day; and avoid crocodiles and jackals when feeding or roosting on the ground. Day in and day out, those are the basic elements of an Osprey's life along this West African coastline.

Elsewhere in Africa we find a few Ospreys wintering as far south as South Africa, at least 6,000 miles (10,000 km) from southern Finland. Likewise Mo-

Seasonal wetlands in the Sahel region of Mali, West Africa, provide key stopover and wintering sites for European Ospreys that have crossed the Sahara desert. Local tribal people make use of these as well.

2015
KHADIMOU RASSOUL

A European Osprey wintering along the coast of Gambia, West Africa. Local fishermen here depend on many of the same fish that Ospreys catch, but rather than resenting the birds, the fishermen seem to revere them.

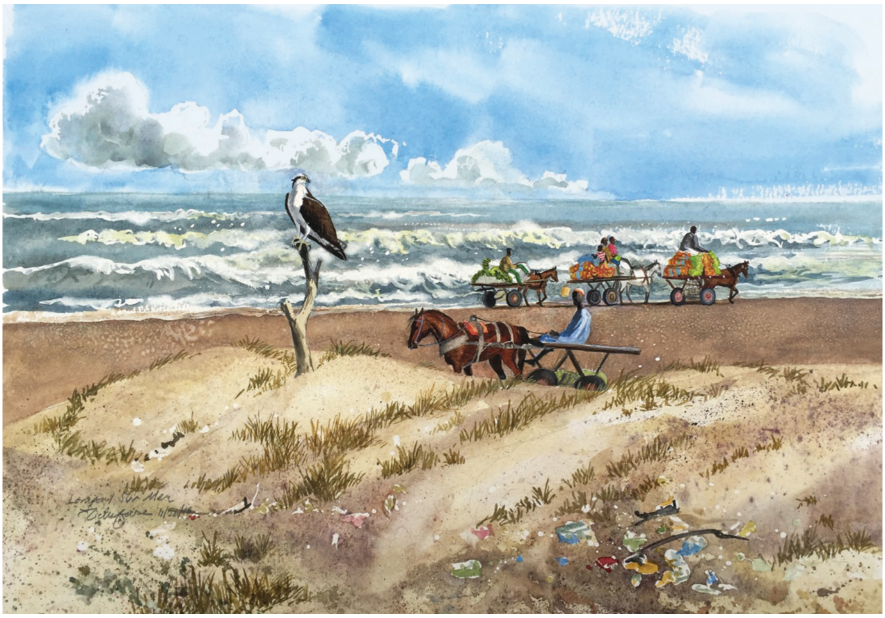
zambique supported a Finnish Osprey with a satellite transmitter in two consecutive winters, and there are hints that others winter there as well. Traveling one January along Rift Valley lakes in the East African countries of Kenya and Tanzania, I saw a handful of Ospreys on most days, but no concentrations; all were likely breeders from western Russian forests. On average, Swedish Ospreys winter 10°–15° west of those from Finland, with Finnish birds west of those from Russia (although there is considerable overlap), as we'd expect, given the longitudinal separation of those countries. But generally all Ospreys in Africa are wintering

Wintering Ospreys along the coast of Senegal, West Africa. Here the birds often form small flocks with individuals resting close to one another, behavior that would not be tolerated on breeding grounds where nests (and sometimes feeding sites) are often vigorously guarded and defended.

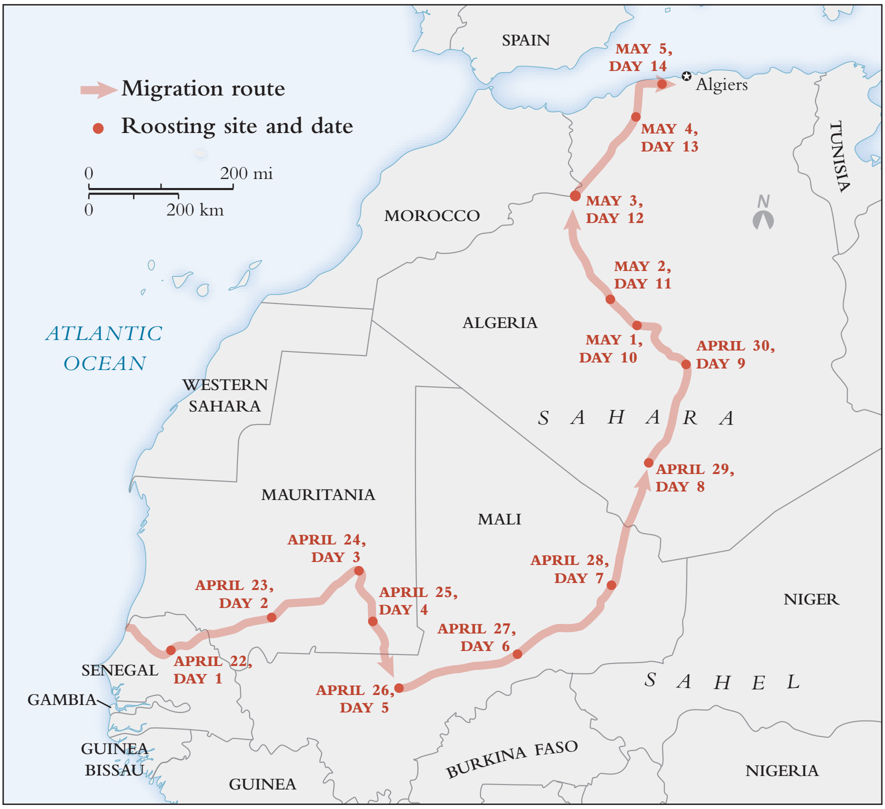
west of breeding grounds by about 20° of longitude, reminding us that these birds are flying not just south in fall migration but are trending west as well.

For all the Ospreys finding winter homes in Africa, the return migration in spring follows roughly the same route as in fall, but it is flown more quickly, owing to fewer stopovers. The birds are not flying faster on the days they travel but are just stopping less often, probably because they have less need of food and rest. After a winter of easy fishing and relative inactivity they likely have the body reserves they need to complete their journeys efficiently. In short, a well-nourished Osprey is likely to be a quick migrant. Perhaps just as important, there is the urgency of returning to nests in time to claim them. We have seen what happens to individuals that come back late to a nest—often their mate has taken another partner or the nest has been usurped by other birds.

Even though males and females are traveling at about the same speed, males usually arrive first at the nest, at least a few days ahead, suggesting they start migration earlier. The timing of migration seems to be staggered in relation to breeding latitude as well, with breeders from France and Germany, for example, leaving a week or two earlier than those from Finland, 1,200 miles (1,900 km) to the north and east. Among Finnish Ospreys, however, those breeding in the south of that country and in northern Lapland (600–900 miles [1,000–1500 km] apart) leave at about the same time, although the latter travel more slowly (253 vs. 185 km per day). All this suggests that migration schedules are set by an internal clock each bird has developed on its nesting grounds, with that flow of hormones turned on and off as the bird works through its annual cycle.



Ospreys and humans share beaches in Senegal, West Africa. Despite brisk human traffic on these beaches, the density of wintering Ospreys here is as great as anywhere on earth. Surrounding ocean and estuary waters produce abundant fish of many different species.


SPAIN
MAY 5, DAY 14
Algiers
Migration route
Roosting site and date
0
200 mi
0
200 km
MAY 4, DAY 13
TUNISIA
MAY 3, DAY 12
N
MOROCCO
MAY 2, DAY 11
ATLANTIC OCEAN
ALGERIA
MAY 1, DAY 10
APRIL 30, DAY 9
WESTERN SAHARA
S A H A R A
APRIL 29, DAY 8
MAURITANIA
MALI
APRIL 24, DAY 3
APRIL 28, DAY 7
APRIL 23, DAY 2
APRIL 25, DAY 4
NIGER
APRIL 27, DAY 6
APRIL 22, DAY 1
SENEGAL
APRIL 26, DAY 5
S A H E L
GAMBIA
GUINEA BISSAU
GUINEA
BURKINA FASO
NIGERIA

Migration tracks of a young satellite-tagged Osprey from northern England (Northumberland) on its first migration north from wintering grounds along the coast of Senegal. This fourteen-day marathon journey across mostly desert terrain is extraordinary. The following year it took a more direct route on its migration north.

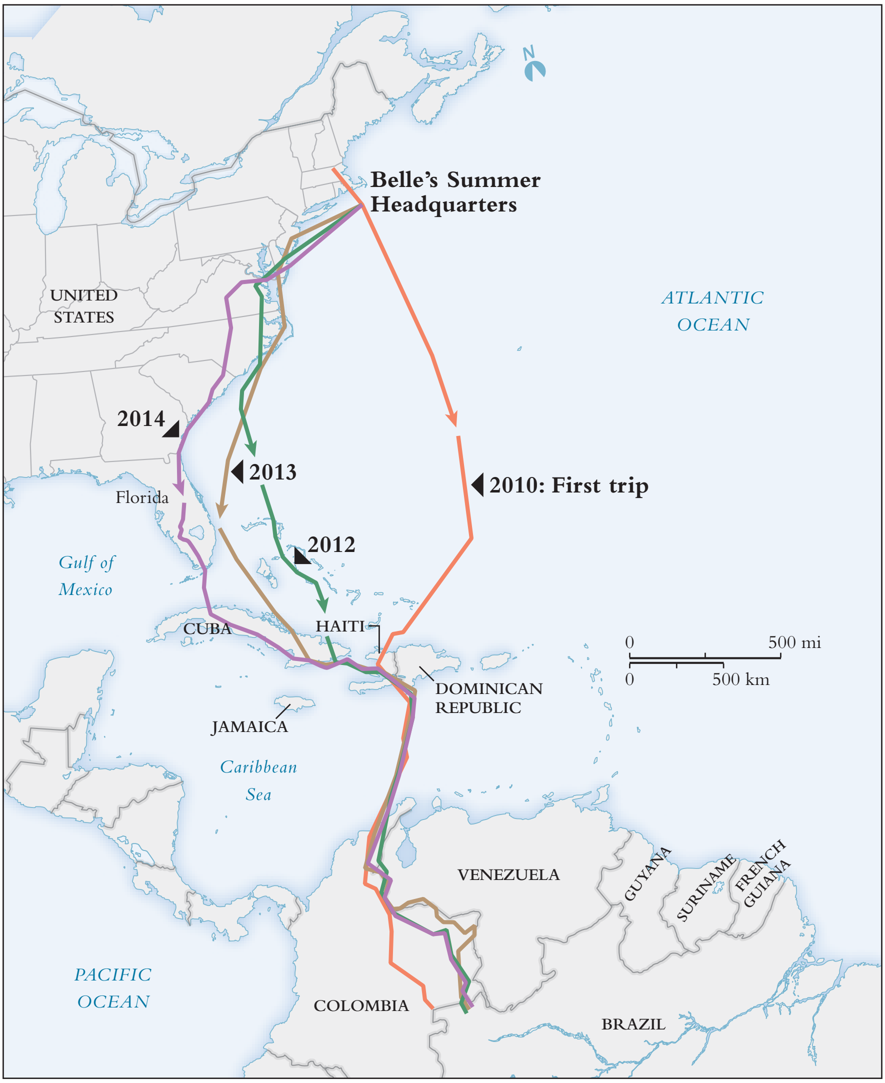
NORTH AMERICA: TO AMAZON RIVERS AND MEXICAN LAGOONS

While January finds more than 90% of Europe's Ospreys south of the Sahara, settled into Central and West Africa, a similar winter snapshot for North America shows the species to be far more dispersed, especially north to south. Two regions hold the majority of America's Ospreys in winter: (1) the northern third of South America, from roughly 10° below the equator up to the coastlines of the southern Caribbean and the western Atlantic, and (2) the Pacific coasts of Central America and northwestern Mexico. Thus significant numbers of American Ospreys are spread over at least 35° of latitude (2,500 miles) in winter, while their European relatives are concentrated in a band about half that wide north to south.

The geography of nesting grounds explains much of this difference. Ospreys nesting in the western third of North America funnel into Mexico and Central America on their fall migrations and there encounter a favorable climate, warm waters, and plentiful fish. No need to travel farther, and no surprise this region has become such a key wintering area for Ospreys breeding in regions as far apart as Alaska, British Columbia, Montana, and Colorado. Farther east, in central portions of the continent, most of the migrants tend to funnel through eastern Mexico, or across the Caribbean and on into South America. And for eastern North American Ospreys, breeding anywhere from the Great Lakes to Labrador to Chesapeake Bay, the Atlantic seaboard is the key migration highway, with Caribbean islands a helpful bridge in crossing that great sea.

Examined in more detail, these migrations provide a fascinating study in contrasts. The eastern migration route is perhaps best known because so many (over one hundred) eastern US Ospreys have been tagged with transmitters around the turn of the twenty-first century, and thousands of that region's fledglings were banded in the decades before that. The great majority of Ospreys nesting east of the Great Lakes migrate south along the Atlantic coast or within a few hundred miles of it. This is a fish-rich ribbon of coastline during late summer and early fall when Ospreys take to the wing, so it is hardly surprising that inland nesters gravitate east to this route and that coastal nesters never leave it. Hawk watchers at legendary Cape May Point on the southern New Jersey coast see at least three to four times as many Ospreys each fall as watchers 150 miles inland at Pennsylvania's Hawk Mountain do. Here again we are reminded of a species flexible in its migration strategy, less dependent on the thermals and mountain ridge updrafts that the broader-winged soaring hawks and vultures need to stay aloft on their migrations.

Farther south, these Ospreys begin to narrow their migration path when they reach the Florida peninsula, especially when heading into the Florida Keys, that 100-plus mile (160 km) string of small islands that helps launch Ospreys on their seaward path to South America. A few, about 5%, linger in Florida for the winter

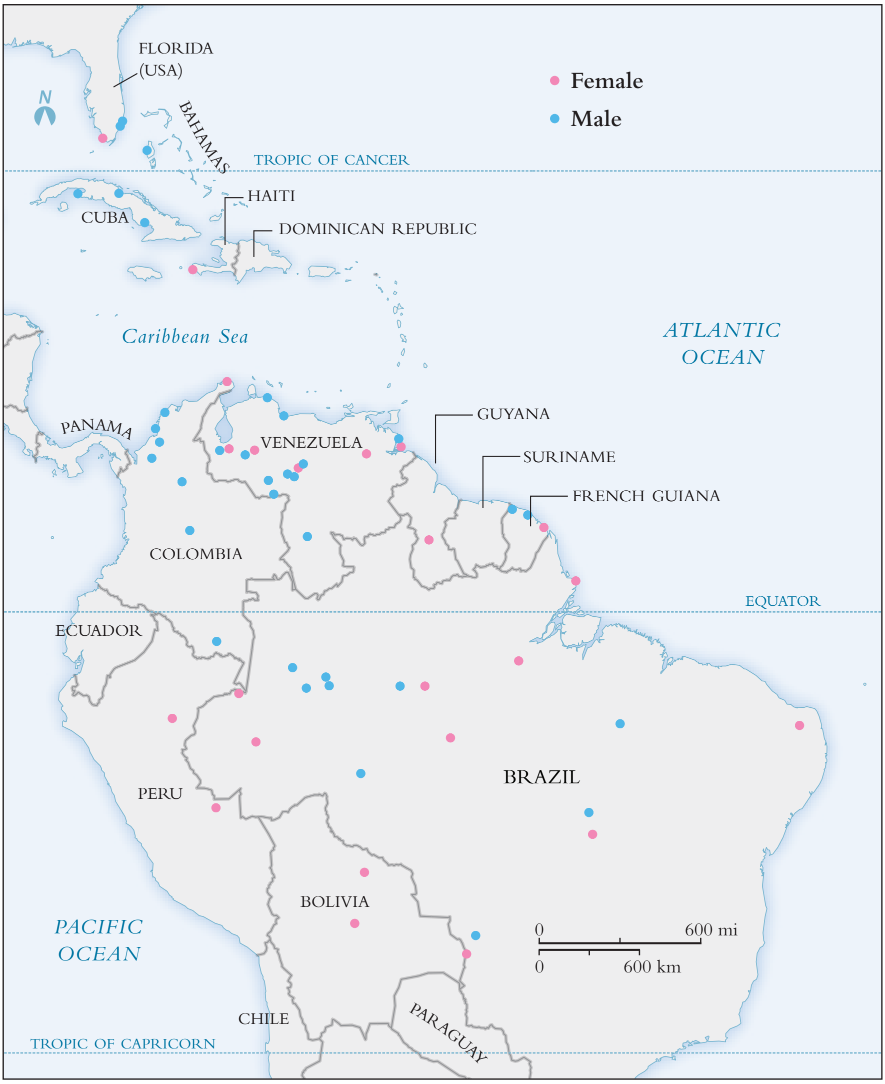

Belle's Summer Headquarters
ATLANTIC OCEAN
UNITED STATES
2014
2013
2010: First trip
2012
Florida
Gulf of Mexico
CUBA
HAITI
DOMINICAN REPUBLIC
JAMAICA
Caribbean Sea
0
500 mi
0
500 km
VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA
PACIFIC OCEAN
COLOMBIA
BRAZIL
N

Learning the best route: the first leg of four fall migrations of Belle, a satellite-tracked Osprey from coastal Massachusetts, USA. Her first migration south as a naïve juvenile (in 2010) involved a long and dangerous flight over the open Atlantic Ocean. Note how each migration in subsequent years put this bird closer to the US coast, the standard (and safer) track of most eastern US Ospreys moving south in fall.

but most use the Keys as their jumping-off point for Cuba, 90–100 miles (144–60 km) south across warm salt waters. Hawk watchers on the Keys routinely count more than 1,600 Ospreys passing along that island chain each fall, with up to 400 a day during peak migration in early October. Here we begin to appreciate how robust and concentrated this flow of North American Ospreys really is; no site in Europe comes close to recording this many Ospreys in any season.

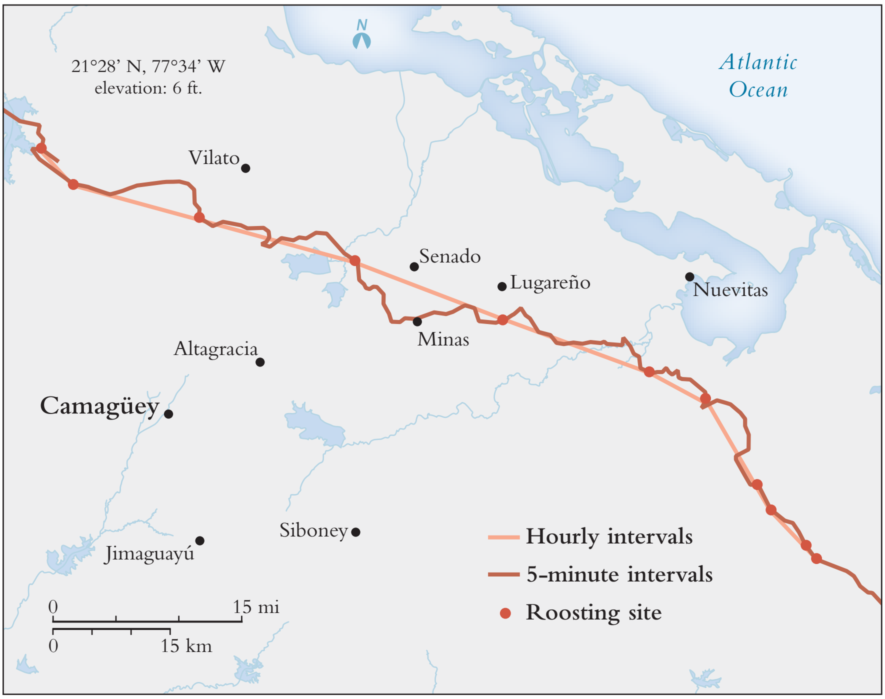
Cuba is just four to five hours south of Florida as the Osprey flies, so the crossing is not especially challenging for these birds, although they do have to make the decision to give up land for open water. But once they reach Cuban shores they tend to fly east and then stop to feed for a few days, often at inland freshwater sites. At the Alacranes Reservoir west of Havana, for example, gatherings of ninety to one hundred Ospreys are not unusual at peak migration times

Wintering locations of satellite-tracked Ospreys that nest in the northeastern United States. On average, males winter north of females: 70% of the males shown here are north of the equator, while females are about equally distributed north and south of that line.


FLORIDA (USA)
N
BAHAMAS
● Female
● Male
TROPIC OF CANCER
HAITI
CUBA
DOMINICAN REPUBLIC
Caribbean Sea
ATLANTIC OCEAN
GUYANA
PANAMA
VENEZUELA
SURINAME
FRENCH GUIANA
COLOMBIA
EQUATOR
ECUADOR
BRAZIL
PERU
BOLIVIA
PACIFIC OCEAN
0
600 mi
0
600 km
CHILE
PARAGUAY
TROPIC OF CAPRICORN

in early fall; many are seen with fish. And it is not only reservoirs that feed these birds. Cuba is a land of fishponds, big business in a protein-hungry nation but often a danger to Ospreys. Far too many of our satellite-tagged migrants have been shot on this leg of their migration, lured in by captive fish whose owners were less than enthusiastic about having to share their bounty with newly arrived visitors from the north.

Most survive, however, and work their way east toward the large island of Hispaniola, their last stop before crossing the Caribbean. For south-trending migrant Ospreys, it is interesting how readily these birds (especially naïve juveniles on their first trip south) find and follow this easterly route, but Cuba trends south as well as east, so it could be they sense this land bridge for its southerly tilt. In any case, only a few fly directly south across the island and on into Caribbean waters, a trip that would add hundreds of overwater miles to their migration. Instead, turning east, they flow through central regions of Cuba and on to the eastern coastline, with their passage especially well documented in the Sierra Maestre, a range that extends 180 miles (300 km) parallel to the coast of southeastern Cuba. Extraordinary flights are seen there each fall, now well documented thanks to efforts by Cuban biologists and birders, led by Freddy Rodríguez-Santana from Cuba's National Museum of Natural History. Up to seven thousand Ospreys pass through this site in most years, with flocks of fifty or more not unusual at peak times. No other site in the world concentrates Ospreys like this one, with scattered reports from mountainous regions to the north suggesting many more pass through there as well. Clearly Cuba is a major Osprey thoroughfare, a fact unappreciated until recently. Biologists now suspect that 80%–90% of the over 50,000 Ospreys migrating from eastern North America pass through Cuba on their way south each year, and on their return trips north in spring.



Migration track of Woody, an adult male Osprey from Chesapeake Bay, USA, on his fall 2015 migration through Cuba. Woody was fitted with one of the advanced GMS cell-tower transmitters, which provided a location fix every few minutes. As a result, we can see Woody's travels in detail. The orange line here shows a route plotted from GPS fixes every hour, which is what older, satellite-based transmitters would have given us. The red line, with fixes every ten minutes from the newer GMS transmitter, shows his true path, suggesting Woody was hunting for thermals to get a lift. Notice how, despite wandering as much as 3 miles (5 km) off course in that search, this bird had a clear overall sense of direction.

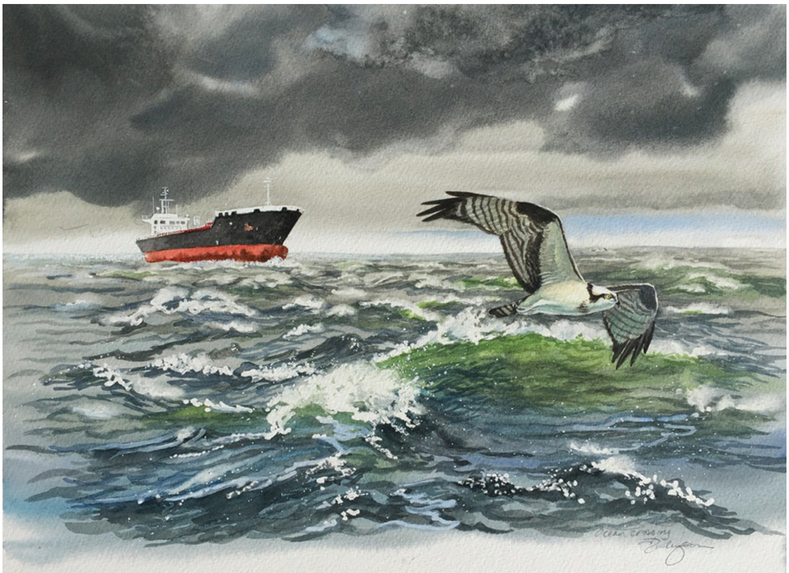
The American writer David Gessner visited the Sierra Maestre mountains in 2006 while following Ospreys in their fall migration. His book *Soaring with Fidel* is an entertaining look at migrant Ospreys and the people who track them. He captures the excitement that overtook Cuban biologists when they first began to realize just how remarkable these concentrations were:

> on one glorious day in August of 2003 as he stood atop La Gran Piedra in the Sierra Maestre, Freddy Rodriguez confirmed all he had suspected. While he watched, over six hundred Ospreys streamed and soared along the beautiful mountain ridge toward the peak where he stood. The huge chocolate-brown and white birds seemed to materialize out of the clouds above the city of Santiago and fly at him in flocks of up to fifty birds—*flocks!* No one had ever heard of Osprey flocks before—while he clicked away on the mechanical counter he held in his hand. . . . By late afternoon the birds slowed to a trickle and the numbers had already passed 600, but Freddy stayed up top until dark to make sure he was there to count the last, the 607th, Osprey.

In the hot, humid climate of western Cuba, daytime thermals power much of this migration, with Cuban Hawk Watch data suggesting that some Ospreys feed and spend their nights along the coast and then move inland to ride high over the mountains on daytime thermals. The energy saved there may help on the next leg of their migration, which becomes more challenging. Although a few stay on to winter in Cuba, the vast majority follow the migration highway east across the Windward Passage to Hispaniola, a short (50-mile [80 km]) hop over Caribbean waters into the sadly degraded landscapes of Haiti, the western half of Hispaniola.

Most migrants don't linger. Instead, their destination is south and east to a seemingly unremarkable peninsula that juts 30 miles (48 km) out into the Caribbean—Cabo Beata, the southernmost point on the island of Hispaniola. If any portion of the Osprey highway rivals the concentrations seen in western Cuba, Cabo Beata is it. But this is a remote, inhospitable, mosquito-infested sliver of the Caribbean and no one has been there to document the Ospreys passing overhead from late August to early October. We only know this key piece of the route because the tracks of over fifty satellite-tracked Ospreys appear to be on rails there. One after another they funnel down this peninsula, hardly any missing the chance to shorten the overwater portion of their journey by following this modest land bridge south into the Caribbean Sea. Forty-eight kilometers may not seem like much (an Osprey could fly that distance in an hour), but as we've seen migrating Ospreys are masters at finding routes that limit the overwater distances they have to cover.

At the southern tip of Cabo Beata, however, they have reached the end of their rope, so to speak. Confronted with nothing but ocean waters south of them, they are forced to commit—heading out on a roughly 500-mile (800 km) flight across the southern Caribbean to the north coast of South America. For most, this part of the migration holds the greatest dangers, especially in fall when the Caribbean is brewing hurricanes. Perhaps Ospreys can sense when a big storm is building, and hold off on migrating, but given the long distances involved it is probably difficult for them to anticipate what lies ahead, whatever senses the birds may use to detect storms. In big hurricane years at peak migration times, the loss of Ospreys is likely significant. A handful of satellite tracks in this region show individuals



Open ocean crossings are hazardous for migrating Ospreys, especially for juveniles on their first flight and for individuals of all ages during storms. Nevertheless, tens of thousands of Ospreys routinely make such crossings each spring and fall, particularly in the western Atlantic and Caribbean and across the Mediterranean.

A tributary to the Amazon River in northern Brazil, surrounded by intact forest. At least 30%–40% of North America's breeding Ospreys depend on such habitat each winter, fishing the Amazon's many rivers and lakes.

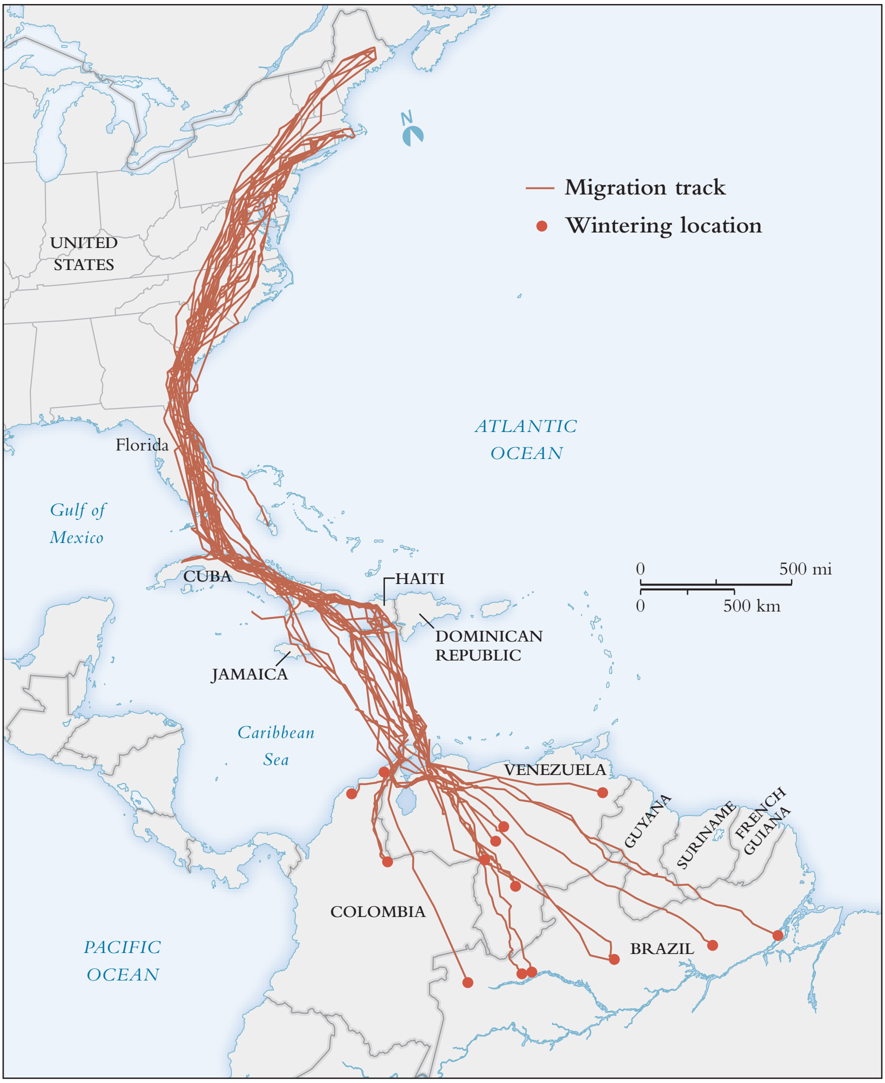
blown far off course in autumn storms, with most of these birds failing to recover and reach land, and others maintaining a fairly direct southerly track, but not making landfall. They simply run out of energy and die. In stark contrast, no satellite-tagged bird has been lost crossing that same water in spring.

The vast majority of fall migrants succeed in crossing the Caribbean and at least 70%–80% of these birds appear to make landfall around the Gulf of Venezuela, at the border of Venezuela and Colombia, due south of Cabo Beata. From that point on the north coast of South America, they tend to funnel south to productive waters in and around Lake Maracaibo, just a few hours' flight inland. Some linger there for a week or two, especially the younger birds, feeding and resting after fifteen to twenty hours at sea with no food, but almost all eventually move on, dispersing widely into South America. Band returns and satellite data show that about 70% of these birds find wintering sites on inland rivers and lakes, with the rest settling along Caribbean or Atlantic coasts.

It seems extraordinary how far some of these birds travel, almost doubling their overall migration distances by heading south and east another 1,500–2,000 miles (2,400–3,200 km) into southern Brazil and northern Argentina. Apparently the migration drive in some Ospreys—whatever portion of their brain tells them to keep moving—is stronger, or turned on longer, than it is in those that stay behind to winter in Florida or northern South America. In any case, no matter where they settle down, satellite data show how amazingly faithful individual birds are to particular wintering locations, often just a square mile or two of river or lakeshore, and how unerringly they track across vast Amazonian landscapes to find their winter homes.

Spring migration for these eastern American breeders is roughly the reverse of fall, but faster and more direct. As with their European relatives, it appears that these birds fly no faster than they do in fall but simply stop less often, probably because they have solid body reserves after a sedentary winter. When we look at maps of satellite-tracked Ospreys flying north from South America, we see that nearly all funnel back through the Gulf of Venezuela, a remarkable concentration despite coming from widely separated areas, some more than a thousand miles apart. And we see that at least half short-cut the Caribbean leg of their journey by flying directly to Cuba, probably riding westerly trade winds instead of dog-legging through Hispaniola; that Cuba remains the major thoroughfare it was in fall, as does Florida; and that while the migration front broadens as the birds move north along the US Atlantic coast, it is narrower than in fall—further indication of a pressing drive to return to nests.

Young birds, in their second spring and still a few months shy of turning two years old, are on their first migration north. They often overshoot in Cuba, failing to turn north for Florida and continuing west into the Gulf of Mexico before finding a northern track across water, making landfall along the central


N
— Migration track
● Wintering location
UNITED STATES
Florida
Gulf of Mexico
ATLANTIC OCEAN
0
500 mi
0
500 km
CUBA
HAITI
DOMINICAN REPUBLIC
JAMAICA
Caribbean Sea
VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA
COLOMBIA
BRAZIL
PACIFIC OCEAN

Spring migration routes of satellite-tracked Ospreys heading to breeding sites in the northeastern United States from wintering sites in South America. Of interest here is how many of the birds funnel through northwestern Venezuela, where peninsulas help shorten the distance across the Caribbean Sea. Note too how many of these Ospreys fly through Haiti to Cuba and how close together the tracks are in Florida and further north—truly a migration highway.

Gulf coast of the United States. Interestingly, the few that were tracked on their second migration north appear to have learned from their mistakes and reset their compasses, following the standard shorter route north into Florida.

Ospreys become remarkably concentrated in northern Venezuela before they launch out each March over the Caribbean. David Gessner, the wandering tracker of Osprey migration in the Americas, made a pilgrimage to north-coastal Venezuela in early spring to try to locate Ospreys there. Before his trip, no one had imagined that Ospreys gathered in any numbers on their South American wintering grounds. But just north of Caracas David found over one hundred Ospreys on a short stretch of a polluted lake that was teeming with tilapia, an introduced fish and clearly a major draw for Ospreys. This was prime time for the Ospreys—the birds were pushing north in migration, and productive habitat lured them in.

Once again we see a species that can form dense concentrations under the right circumstances, and we're reminded how even polluted waters can often provide the resources these birds need.

The migration patterns of western North American Ospreys are almost as well known as those that nest in the eastern half of the continent, thanks again to significant efforts with satellite-tracked birds. These western Ospreys, as we saw in chapter 3, are mostly freshwater lake and river nesters, breeding anywhere from Alaska to Saskatchewan to Colorado and California. Looked at from a global perspective, these birds face among the least challenging migrations of any Ospreys on the planet. For one thing, they have no major bodies of water to cross. And although their flights are often over semidesert lands they rarely travel more than a day or two without encountering a river, lake, or reservoir. With the exception of breeders from Alaska and northern Canada, the migration distances they have to cover are at least 20%–30% shorter than those faced by most other Northern Hemisphere Ospreys, with Mexico and Central America offering prime wintering sites, so they are spared the longer trip into South America.

Because Western populations are widely scattered, it is hard to generalize about the routes these birds follow, but many traverse remote stretches of dry open landscape between the two major mountain ranges of the western United States—the Sierras and the Rockies. Individuals nesting closer to the Pacific, especially west of the Cascade Mountains, tend to fly south along those foothills, and also along the Sierras, then through central California to the west coast of northern Mexico. There, especially along the coast of the Mexican state of Sinaloa made infamous by warring drug lords, and adjacent Nyarit to the south, Ospreys find winter homes on coastal lagoons, where warm, shallow waters nourish abundant fish. Satellite tracking data show a small percentage of birds continue south into Central America as far as El Salvador and Costa Rica, and there are records of surprisingly large concentrations on a few lakes and reservoirs in central and southern Mexico. The eastern Mexican state of Veracruz also seems to attract many wintering birds, with breeders from southern British Columbia found there along coastal lagoons, as well as significant numbers inland at freshwater lakes.

For many of these western migrants there is a tendency to travel quickly—migrating fewer days and farther each day with fewer stops than their counterparts farther east in the Americas. This may be because fishable waters in those arid western landscapes are scarce, or simply because the shorter distances these birds have to travel reduce their need for conserving body reserves. Calculations show it is possible for an Osprey to migrate from Oregon to Sinaloa, Mexico, with just three to four full-day stopovers for food and rest, given that these birds often complete these trips in fifteen to twenty days. Satellite data show that many individual birds complete longer trips with no full-day stopovers at all, probably fishing only in the early morning and evening when they stop to rest for the night.

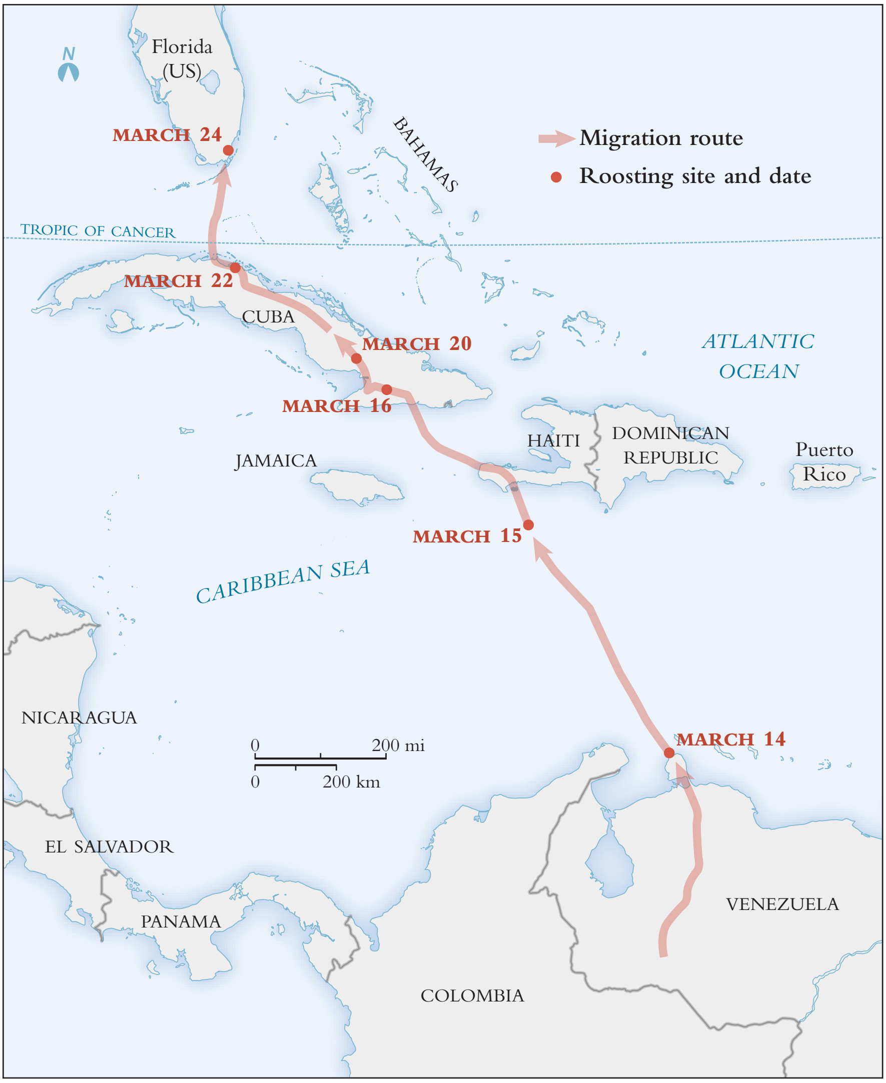
NORTH AMERICAN OSPREYS IN WINTER

In childhood I spent hours poring over maps and atlases, mesmerized by the vast and varied landscapes of countries I'd never heard of, and of oceans whose coastlines I longed to visit. For Osprey enthusiasts today, Google Earth maps have revolutionized our understanding of migration routes and wintering locations, giving us looks at the habitat and geography that support these migrants in regions that remain unfamiliar to most of us.

What is striking about the sites these Ospreys find is their diversity. No single landscape typifies what wintering American Ospreys find attractive—no region in the southern Americas appears to concentrate the birds in winter the way the coasts of Senegal and Gambia concentrate European Ospreys. So we focus on three tropical habitats that we know satellite-tracked American Ospreys have used. Two are along seacoasts, where the birds depend on estuarine and marine habitats, and one is a river site—a tiny slice of one of the thousands of rivers that drain the vast Amazon basin.

We have particularly good tracking data from Crabby—a two-year-old female Osprey trapped at a nest in Chesapeake Bay in 2014 and given one of the more advanced backpack transmitters that stores GPS data frequently and then communicates that information to a central location via cell phone technology. Crabby flew from Chesapeake Bay to Venezuela in three weeks, pausing there to rest and feed for eleven days before moving on to her permanent winter home along the coast of French Guiana, about 900 miles (1,500 km) to the southeast. This is a remote, hot, humid region of rivers, swamps, and mangrove forests, part of a large nature reserve (Marais de Kaw-Roura) accessible mainly by boat. Crabby would have shared habitats with an extraordinary community of tropical wildlife, including formidably large black caimans (*Melanosuchus niger;* 16 feet [5 m] long), as well as one of the largest known nesting colonies of the rare Agami heron (*Agamia agami*). Tracking data showed that Crabby made use of coastal saltwater habitats, including islets on which she often roosted at night, as well as the lower reaches of rivers that fed into the ocean there. Not surprisingly, this was an area that lacked cell phone reception; in fact, it was only weeks after Crabby left this coast that her data were finally downloaded. As a local ornithologist there put it, when queried for details about the area, and made aware of the cell phone technology Crabby was carrying: "No wonder she didn't call you!"

We see Ospreys relying on similar but less remote habitats along the coast of southeastern Brazil, where the feeding ecology and habitat use of a dozen or so wintering migrants were studied over two years. This region receives an astonishing six feet (1.8 m) of rain each year, most of it in the period when Ospreys are wintering there. Despite such deluges, and despite industrial development that has degraded mangrove forests along this coast, the birds seem to do well there, with


N
Florida (US)
BAHAMAS
Migration route
● Roosting site and date
MARCH 24
TROPIC OF CANCER
MARCH 22
CUBA
MARCH 20
ATLANTIC OCEAN
MARCH 16
HAITI
DOMINICAN REPUBLIC
Puerto Rico
JAMAICA
MARCH 15
CARIBBEAN SEA
NICARAGUA
0 200 mi
0 200 km
MARCH 14
EL SALVADOR
PANAMA
VENEZUELA
COLOMBIA

Ten days in the spring migration of Edwin, a satellite-tracked Osprey from coastal New York State, USA, March 14–24, 2015. Edwin's migration was quick and direct across the Caribbean but slowed in Cuba, where he spent several days roosting and fishing. Fall migrants are more likely to take a less direct route, flying east to the Dominican Republic and then south across the Caribbean.

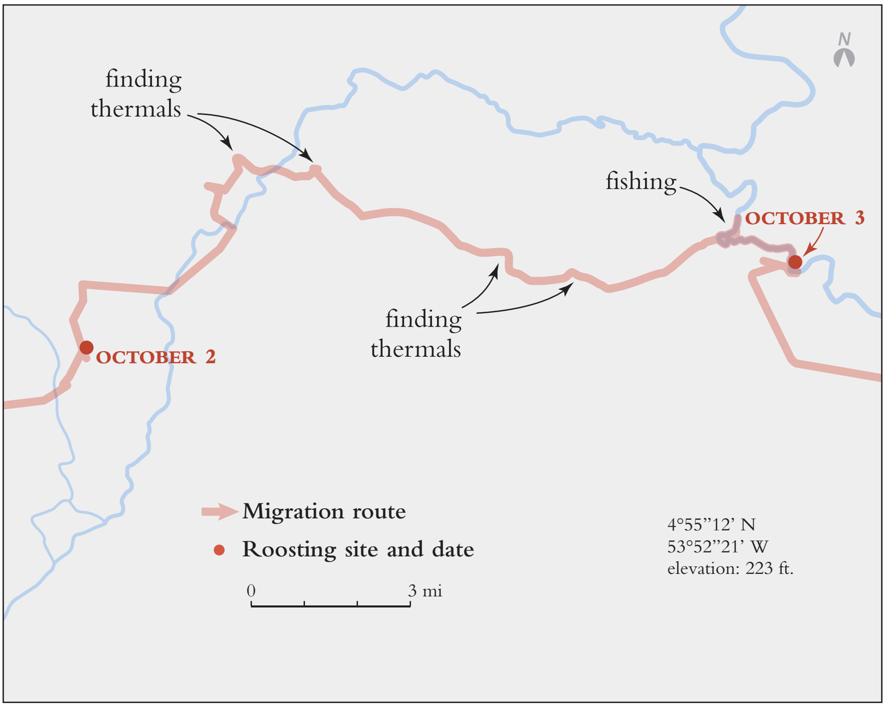
an average of about one bird per kilometer along mangrove-lined estuaries that abut this coast. Mullet are favored prey, with the Ospreys using buoys in the rivers and industrial towers along the edge as their roosts and feeding perches.

So overall we see here a study in contrasts: wintering American Ospreys thriving in a variety of marine and estuarine habitats, from the wilderness seacoasts of French Guiana to the semi-industrial tidal rivers of southeastern Brazil.

Moving inland, Amazonian rivers and lakes are at the heart of the habitat Ospreys choose. A reasoned guess is that North America sends about 120,000 Ospreys south each fall; this includes an average of one surviving young fledged per active nest, a conservative estimate. Rough calculations suggest that about two-thirds of those fly through to South America, with about 70% of those settling on

South American rivers and lakes—most in Amazonian forest. So the Amazon basin is winter home to roughly 60,000–70,000 American Ospreys each year.

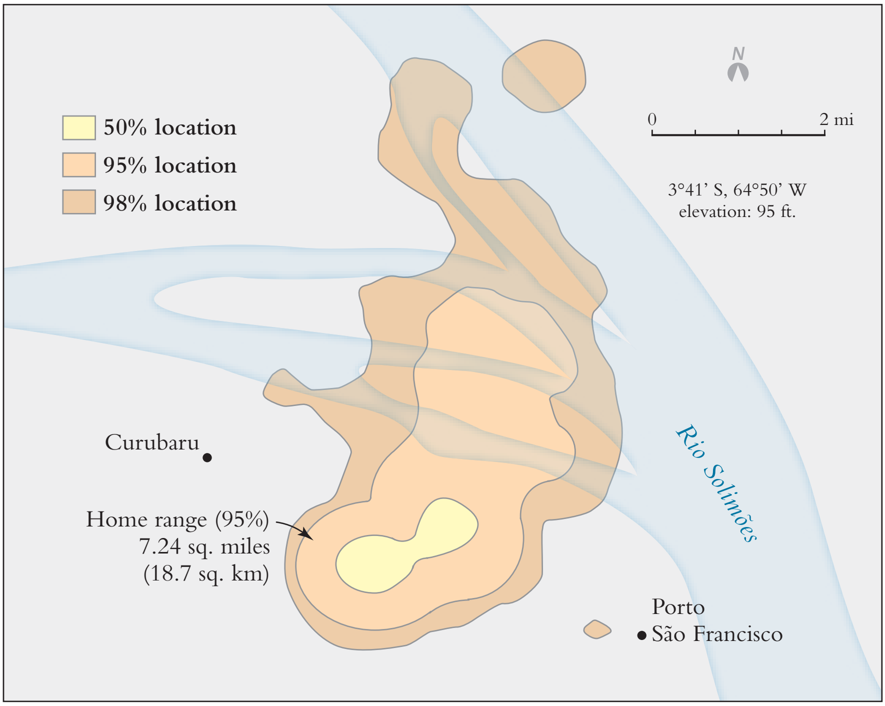
Consider Belle, a now-storied Osprey (the subject of an upcoming children's book, *Belle's Journey*, by Rob Bierregaard). This was a bird that was fitted with a satellite transmitter as a fledgling on the south coast of Massachusetts and that wintered in central Brazil on the southern edge of the Amazon rainforest. Her territory there, made up of a river's edge and an attached lagoon and used over the four consecutive years her transmitter was functioning, was surprisingly small, hardly a mile long and less than half that wide. It appears Belle found all she needed in that restricted area of lake and river. The river (Rio Madeira) is one of the Amazon's whitewater rivers, so called because they transport heavy loads of silt that are often light in color, like coffee with milk. The Madeira is one of the major tributaries of the Amazon, although not large where Belle resided, about half a mile across. Tracks from Belle's satellite transmitter showed her mostly hugging the shore there, probably roosting and doing some of her fishing from perches along the edge, a sit-and-wait, energy-efficient way of getting a daily meal. Rob



A day in the fall migration of Crabby, a US migrant from Chesapeake Bay tracked by cell-tower transmitter to her wintering grounds in Guiana, South America, October 2–3, 2014. Note the details of her migration route revealed by the advanced technology of this GPS transmitter: sharp bends in her route and changes in the altitude of her flight suggest she was riding thermals for part of this trip, and detours and delays along rivers show areas she was probably fishing.

Bierregaard sums up this life of an Osprey wintering in the Amazon: "What a life. Hang out in a tree until you see a fish near the surface, swoop down and catch it. Back up to your perch for a good meal, settle in for twelve hours sleep, and then do it all again tomorrow!"

Mexico holds significant numbers of Ospreys in winter, fairly evenly divided between inland lakes and reservoirs and coastal lagoons and shorelines. Little is known about these inland Ospreys, especially in areas where they concentrate. Coastal lagoons get more attention (they are fishery nurseries), although not necessarily the Ospreys using them. An abundant fish in these waters is the white mullet (*Mugil curema*); as we've seen, where there are mullet Ospreys tend to thrive. Mangrove fringes to these lagoons help power this ecosystem. Their dropped leaves form the base of the food web, and their flooded prop roots, colonized by dozens of marine organisms, are a key part of the nursery grounds that protect and nourish the fish that Ospreys depend on. Human visitors cannot help but be charmed by these lagoons. In the northern winter months when Ospreys are there,



Five months (March 29–October 4, 2014) in the life of Artoo, a New Hampshire, USA, Osprey tagged with a satellite transmitter as a fledgling in the summer of 2013. Here we see where he spent the following spring and summer (as a 1- to 2-year-old), along a tributary to the Amazon River in Brazil. Note how little he traveled in these months, moving only a few miles in any direction, as is typical of Ospreys on their wintering grounds.

the waters are usually bathed in sunlight, dazzling by early morning and almost blinding at noon. The horizons out over fringing beaches and the ocean beyond are boundless. Softly and subtly plumed herons, egrets, and sandpipers grace the shallows, often feeding actively or resting in small flocks along the edge of the mangroves.

I remember visiting one of these sites along the Pacific coast of Mexico in February and finding Ospreys daily, hovering over lagoon waters for fish or gliding along beach edges. Lining many of these beaches were small, open-air Mexican restaurants, usually catering to a lunch crowd (Mexicans are masters at spending long afternoons eating lunch with family and friends). Inevitably there were mariachi bands playing at these spots, their festive music carrying along the beach and far out over the water. Once again I was struck by the anomalies in the life of a migratory Osprey. Here were possible nesters along remote wild rivers in Montana or Oregon or British Columbia, fishing alongside Mexicans dining to the tunes of mariachi bands.

A critical finding from satellite telemetry data is how faithful individuals are to wintering locations, often just a mile or two of river or lakeshore, and how unerringly they track across vast Amazonian landscapes, hundreds of miles or more, to find those spots. But wherever Ospreys spend the winter, we inevitably come back to a central question: how do they get there? Navigating thousands of miles in just a few weeks, often over unfamiliar territory and trackless seas, alone. We stand humbled before these feats, particularly those of fledglings just out of the nest, on their first migration south. Studies in the last few decades—not just of Ospreys but of a variety of other birds migrating long distances—have begun to open doors to the mysteries of avian navigation.

NAVIGATION AND SURVIVAL: NIGHTS OVER THE OCEAN, DEATH IN THE DESERT

The first decade of the twenty-first century was a busy one for researchers interested in Osprey migration. Satellite-tracking technology was developing fast, with longer-lasting batteries (solar-charged) and GPS precision to location fixes. And the successes of pioneering research groups encouraged others to get on board. Over one hundred Ospreys were fitted with transmitters during those years, tracking their journeys with unprecedented accuracy. Keep in mind that each of these transmitters was sending a location fix at least once an hour (once every few minutes for birds tracked by cell-tower transmitters), producing hundreds of thousands of data points for each bird, millions for each of the populations studied. But the tracks of a few dozen of these birds caught the attention of biologists because they showed travel across areas so vast, empty, and featureless—the Atlantic Ocean and the Sahara Desert—it seems hard to believe that any Osprey could navigate and survive the trip. Yet survive it they did, most of them at least, and year after year others come after them along similar routes. In fact, it can be fair to say that these journeys are almost routine for Ospreys.

Take the nine young fledglings tagged by Rob Bierregaard over the years 2007–11 on the island of Martha's Vineyard, along the south coast of Massachusetts, USA. These were naïve Ospreys starting out on the first migration of their lives, only three-and-a-half months out of the egg and maybe a month and a half on the wing. Before leaving, only one of these birds had flown more than 5 or 10 miles from its nest or more than a few miles at night. Yet one by one, alone, in their various years from their various nests, each of these birds took off on a September day and flew nonstop south over the open Atlantic Ocean to islands in the Caribbean Sea, a journey of at least 1,250 miles (2,000 km) and thirty-six to fifty-four hours of continuous flight.

In human terms we might think of this as the equivalent of sending a teenager on a bicycle trip (Ospreys fly at about the same speed as a human can ride a bike) halfway across the United States or Europe, with no food or water and no cell phone or GPS. However, the teenager would have roads and signs and plenty of company along the way. In stark contrast, the Ospreys making this overwater marathon had nothing—no visual landmarks, no stopover spots, no chance of finding food or a place to eat it, no companions, and no parental guidance. And, of course, no chance of landing on the water. Unlike a gull or a duck, Osprey plumage soaks through quickly on the water and the birds die within hours if they attempt to rest there.

Anyone who has spent time on the open ocean can appreciate what these birds were up against, especially at night. The horizons are vast, the waters trackless, the winds constantly changing and often fierce, and reference points are nonexistent, especially on dark, cloudy nights. One stands in awe of these young birds launching out into the unknown, and we struggle to comprehend the urge that sends them on their way.

What we do know is that these birds were showing precision in their navigation that is almost beyond belief. Not only were they flying faster, farther, and for a longer time across an unfamiliar ocean landscape than anything in their past had prepared them for, they were doing so in a series of arrow-straight tracks that showed constant course correction. Prior to GPS, any ship's captain would have been lucky to navigate half as accurately. Compared to what sailors call a "rhumb line"—the shortest straight-line distance between two points—the tracks of these nine oceangoing Ospreys differed by just 1%–2%. Put another way, at the end of flying a 600-mile (965 km) leg, they were, on average, no more than 6–12 miles (9–19 km) off a straight-line course. Data show these birds were continually buffeted by winds, some as strong as 40 miles per hour (64 km per hour), from many different directions. Not only were the birds correcting for wind drift, but they also adjusted their speed—how much effort they put into flight—

with changing headwinds and tailwinds. Remarkably, they flew fastest into headwinds—flying harder to compensate—and eased off with tailwinds, resulting in near-constant ground speeds hour to hour and day to day, saving energy in the process.

Clearly these birds knew where they were and where they were headed, shifting course continually, minute by minute, in order to stay on track. Not all Ospreys are able to do this, at least not all the time. As we have seen, some lose their way and die and others are sidetracked for part of their trip, often the result of flying into severe weather. But these nine birds show us a species that has the capacity to navigate featureless spaces, even in the dark, with remarkable accuracy. How do they do it?

There is a lot we still don't know about this, but studies focused on other species of birds, as well as on these nine juvenile Ospreys, have begun to tell us a little. Sophisticated analysis by a team of experts from New Zealand, scientists well versed in the field of animal navigation, found one way to explain the super-accurate tracking of these young birds. Their research shows that orientation in relation to magnetic fields—more specifically the magnetic field in the region where each bird fledged—provides a good fit to the data. According to this theory, these fields are somehow locked into the physiology of each bird, probably over a critical period of a few weeks just before and after fledging, and this local magnetic signature becomes the map or template against which changes in magnetism are measured as that bird moves onward in its migration.

A human analogy is to think of this as a hill walk, but on a contour: a path that slopes up and across the hill rather than going straight from bottom to top. Some individuals might take a steeper course; others might be better suited to a gentler one. But central to this theory is that each climber would be aware if he or she switched courses—suddenly the path would be steeper or easier, and the body would sense that difference, leading the individual to correct for it. So it may be with Ospreys. The magnetic chords they follow, similar to those contours on the hill, are likely the threads that lead these birds along, and any shift from one chord to another would immediately register with the animal. Staying on track by following specific arrangements of magnetic chords, or slopes across the magnetic topography, is one way to explain those remarkable minute-by-minute course changes as the young Massachusetts Ospreys flew on with such unerring accuracy.

What are the magnetic fields that Ospreys may be sensing? If we think of the earth as an enormously powerful magnet, with invisible lines of magnetic force running longitudinally between the North and South Poles, like the surface of segments of a peeled orange, we can begin to envision what is at work here. Because these field lines leave the earth at the Antarctic pole and curve around the earth to reenter its surface at the Arctic pole, the magnetic vectors point up-

It is likely that Ospreys can sense the earth's magnetic fields in ways that help them navigate over the long distances they cover in migration. Studies of other migratory birds suggest that the sensory organs used to detect magnetic currents are located in the beak and eyes.

ward in the Southern Hemisphere and downward in the Northern but lie parallel to the surface at the equator, also losing intensity as they move from pole to equator. So changes in the inclination and intensity of these magnetic vectors hold potential clues. Although humans are unable to sense such changes ourselves, any animal that can do so will have a significant advantage in determining its position on the globe and where it is headed.

Biologists have long suspected that birds use the earth's magnetic fields as at least one component of their "map and compass," the two key aspects of any animal's ability to find its way over long and unfamiliar distances. But the how and where of all this have eluded us until recently: how might a bird sense magnetism and where in the body is such a sensory organ located? Crystals of the mineral biomagnetite have been found in the beaks of pigeons (part of the trigeminal nerve) and in the smelling organs of fish, animals known to find natal sites from extraordinarily long distances away. And in songbirds, regions of the brain linked to a protein (cryptochrome) in the eye show "high neuronal activity" when the birds are in migratory mode at night, suggesting that bird eyes may be sensing the world in different ways than the human eye does.

Ospreys likely have similar capacities, although we have no proof of that. But magnetic navigational capabilities have now been found in more than twenty species of birds, and clearly there is great evolutionary advantage in the reliability of this mode of orientation—one that can guide a bird in the dark, in varied weather, and in nearly all parts of the globe. So as we look at an Osprey head-on, in the hand or up close through a telescope, we begin to gain new appreciation for that precisely hooked beak and those intent yellow eyes. There is additional mystery there, an ability to sense the world in ways we can barely imagine.

Magnetic orientation is just one component of bird navigation. Other proven modes include navigating by the position of the sun and the stars. In sun-compass orientation a bird appears to rely on the sun's position in relation to time of day—the migrant keeping a constant bearing, an angle toward the sun, as the sun shifts position during the day. To do this accurately birds need an internal clock, a sense of time that is likely reset continuously by the regular day-night cycle. In addition, stars in the Northern Hemisphere rotate counterclockwise around the polar star, so this north-bearing pole could presumably help orient an Osprey, as it has been shown to do for other smaller birds.

We have no idea if either sun or star positions guide Ospreys. What does seem clear, however, is that the birds have a well-developed memory for landscapes. As we've seen, individual Ospreys often return to the same roosting and feeding spots on their paths along successive migrations north and south, even making detours to reach them. So these birds clearly have intimate knowledge of local landscapes, perhaps even anticipation of what lies ahead, and remarkable memories for sites they haven't seen in months or years.

Overall, redundancy is probably the key. No one migration mode is likely to work in all locations, weathers, or times of day, although it does seem likely that the magnetic component may be often—perhaps always—at work. We may never really know with Ospreys. The best studies of orientation in birds have been done with smaller species that take well to captivity where inputs (magnetic currents, star and sun positions) can be altered experimentally.

Fat, magnetic compasses, the ability to navigate by the sun and perhaps the stars, memory for landscapes: over millions of years Ospreys appear to have honed impressive adaptations for covering long distances efficiently under trying conditions. But even knowing all this, knowing how superbly well adapted they are for these extraordinary journeys, it is hard not to remain just a little incredulous that they can complete these migrations year after year with what seems to be such routine ease.

Knowing how Ospreys move around the globe, and where they go on their extensive migrations, we now turn our attention to some of the threats these birds face. Because they are so mobile, the threats they encounter in one season and region may be very different than those they face in others. How these birds, and the people who manage them, deal with these threats is a fascinating story and reflects not just the resiliency of the species but also how tightly human cultures and the lives of Ospreys are interwoven.

SEVEN

Threats and Solutions

Sixty years ago, Ospreys around the globe were on the edge of a precipice. In Europe, centuries of shooting, trapping, and nest robbing had reduced most populations to mere remnants. Scotland held just a handful of pairs; France, Spain, England, and Italy had none; and Germany was struggling to keep an Osprey flame alive with just a few dozen breeders. Only in Scandinavia and Finland was the species secure, hidden away in large and remote forests where they evaded the worst threats of that era: shooting and (to a lesser extent) contamination from a variety of pesticides.

At the same time, Ospreys in North America were in serious trouble and people in many parts of the continent feared their local populations would go extinct. Chlorinated hydrocarbon insecticides, especially DDT, had been used indiscriminately across the continent since the end of World War II—for pest control in agriculture and forestry and for mosquito control in more populated areas—and the toll that spraying took on Ospreys and other birds of prey is now part of environmental history. DDT and its breakdown products thinned eggshells and reduced breeding success drastically, especially along the US Atlantic coast. Starved of new recruits, populations crashed as older breeders died out, likely hurried along by a toxic brew of contaminants in their diet. Along the coasts of southern New York State (Long Island) and New England, twenty years of pesticide use brought a 90% decline in Osprey nesting numbers, while parts of Chesapeake Bay and the inland Great Lakes lost about half their breeders in that same period. In other regions of North America the status of Ospreys was less well known but the data available suggest that few populations escaped the effects of these contaminants.

The good news was that the plight of Ospreys, along with that of other similarly affected birds, helped bring an end to the use of the most damaging pesticides in North America. Evidence of dying eggs and empty nests tipped the balance in court cases brought to challenge the broad-scale applications of

Adult male Osprey, Massachusetts, USA.

chlorinated hydrocarbon insecticides in forests and fields and marshes across the continent. These were some of the first cases in environmental law, an early precedent for which Ospreys deserve honorable mention.

Today, Ospreys are much better off—certainly not safe from all threats, but faced with problems that seem much less significant than those the species was up against fifty and a hundred years ago. As levels of DDT and other contaminants dwindled, North American Osprey populations rebounded in most areas, like a phoenix rising from the ashes, sometimes even surpassing historical levels. And in Europe, as guns were slowly put away and nests received better protection, Ospreys began to gain in numbers and recognition, even achieving celebrity status in certain countries. Small pockets of trouble remain, but none that threatens entire continental populations in the way that widespread threats did in the early- and mid-twentieth century. Those of us who study Ospreys today, and who came of age in that era of pesticides and guns, are breathing a collective sigh of relief. Yes, we worry about a few populations, but I think it's fair to say we all sleep a lot better at night than we used to. It's a good era in which to be an Osprey biologist.

FISH FARMS AND SHOOTING

Although the data are mostly anecdotal, it seems a safe bet that more Ospreys die today at fish farms than at any other place. Farming fish is a thriving business globally, a significant source of protein for millions of people, especially in developing countries. The problem is that fish farms are also powerful magnets for hungry Ospreys. Thousands, often tens of thousands, of fish are packed into small ponds or holding tanks, sometimes row after row of them, generally in shallow water facilities where the fish congregate at the surface. Ospreys cannot resist such bounty, especially as the fish grow to a size that fits just what the birds are looking for. But like any farmer who stands to lose crops to wildlife, fish farmers take a dim view of having to share their harvest with a bird, especially one that does its damage so conspicuously. The simple (and least expensive) solution in all too many cases is to shoot the offending bird. But as one Osprey dies there is often another to take its place. Over time, the toll at even one fishpond can be significant. Unfortunately, in most cases, and especially in remote underdeveloped areas, we never know what the toll really is.

Ospreys seem to be particularly vulnerable to shooting at fish farms in Latin America and the Caribbean. Of four juvenile satellite-tagged Ospreys that tried to winter in the Dominican Republic over the last ten years, all died near areas with fishponds. In one of those cases the death of the bird was revealed because tracks from its transmitter began to show up on our computers as a steady back and forth between farms and a nearby residential area. It seemed obvious that we were no longer plotting the day-to-day life of a migrant Osprey but instead that of a Dominican fish-farmer making the rounds in his truck, with the transmitter riding on his dashboard.

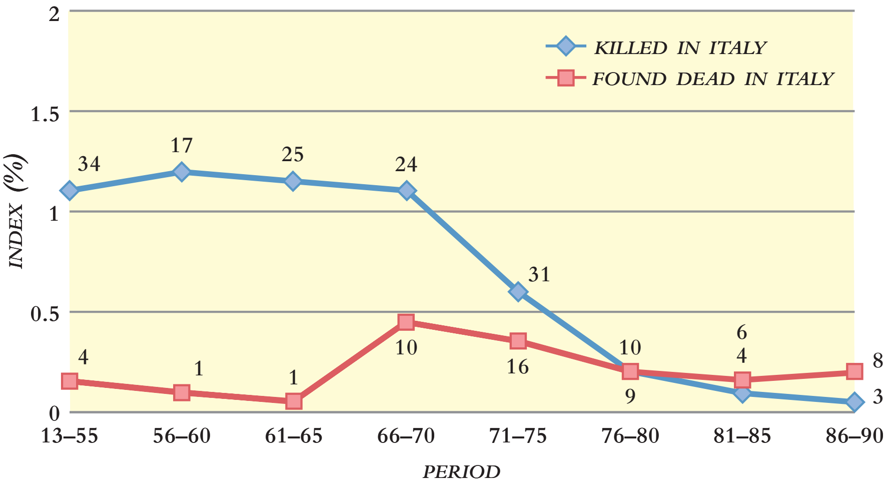
Cuban fish farms are thought to take a toll on North American Ospreys as well, but it is in Colombia and a few other Central and South American countries that we have some of the best information on this topic, thanks to pioneering work by Marc Bechard of Boise State University in Idaho. Marc and his students spent weeks in these countries interviewing fish growers—documenting which kinds

Typical small-scale fish farm in northern Ecuador, a key wintering area for North American Ospreys. Ospreys in these situations are often vulnerable to shooting.

of birds had become problems for them and how the owners were responding to those threats. Ecuador had the fewest and largest facilities, Colombia the most and the smallest; most raised tilapia (*Oreochromis* species), losing up to 16% of their production each year to predatory birds, mammals, reptiles, and amphibians—a significant hit. Ospreys were among the birds causing the greatest losses, so not surprisingly many were shot, with tolls of from two to three hundred and fifty individuals at about two-thirds of the farms each year. Given the two hundred or more facilities surveyed, this represents a significant loss of Ospreys, well into the thousands annually.

There are solutions but they are expensive, at least for those in developing countries. The larger, more prosperous farms Marc surveyed were often able to afford nets to cover their ponds. When properly arrayed, nets help reduce the loss of fish to birds. But few of the smaller farms were able to go that route; shotgun shells are cheaper than nets. Here is where conservationists from developed countries can make a difference. By providing funding and support for nets at fish farms, we can help prevent the deaths of many Ospreys and thousands of other birds each year—a small investment for a big return.

In Europe, where there are far fewer nesting Ospreys than in North America, a long history of persecution at fish farms has likely taken a significant toll. Scotland's Osprey guru, Roy Dennis, has pointed out how the plight of Ospreys and other fish-eating European birds probably stems, to a great extent, from the Catholic religion's edict (starting in the twelfth century) that fish be eaten on Fridays, setting the stage for thousands of backyard fish farms across Europe. As a result, Ospreys were trapped and shot "religiously" at fishponds all across Europe, going back centuries. Add to this the shooting at large hunting estates, especially in Scotland and France, where gamekeepers were paid to protect the sport fish that wealthy landowners spent their vacations pursuing,



Shooting deaths of Swedish and Finnish Ospreys during the twentieth century (1913–90) in Italy. Note that shooting deaths in Italy declined significantly starting in the 1970s. Similar data for Africa show no such decline.

Finnish Osprey Center, Pohtiolampi. This former fish farm now caters to Osprey enthusiasts, both photographers and ecotourists, a model for generating interest in the species.

and you begin to have a prescription for driving a fish-eating predator into extinction.

Happily, much of this shooting is now a thing of the past. Pockets of resistance remain, especially in Eastern European countries like Poland, where fish farms are abundant and wildlife protection spotty; Osprey breeding numbers continue to decline there, likely done in by the guns of Polish aquaculturists. And even in France, where wildlife is better protected than in Eastern Europe, it appears that at least a handful of Ospreys continue to be shot each year on large private estates where the long arm of the law fails to reach.

But looking at the other side of the coin, there are now interesting new developments where fish are farmed deliberately for Ospreys, luring the birds in close for photographers. With a nudge from local biologists, Scottish and Finnish farmers have converted portions of their local trout ponds to Osprey viewing sites, generating significant revenue. It's always encouraging to see the gun replaced by the camera, and this has turned out to be a win-win venture for the few who have tried it.

Alas, Ospreys are shot not just at fishponds but also, in some parts of the world, as they migrate. Such "sport" shooting has been centered in Mediterranean countries for generations. Malta, Sicily, Lebanon, Italy, Turkey, Greece, Crete, and even Spain and France have had the dubious distinction of being countries where hawks, along with millions of other birds, are slaughtered each autumn as they move south to wintering grounds. A good deal of this shooting has slowed in recent decades, but all too often continues. That said, a significant cultural shift can be seen in the generation of young people now coming of age in these regions, especially in Italy, France, and Spain, with an increased reverence for wildlife and many young people seeking careers in the wildlife sciences. To be sure, some of them still hew to the old ways and kill hawks side by side with their fathers, but there is a growing change in the way that Mediterranean people view wildlife, and Ospreys appear to be benefitting.

COLLISIONS: ROADS AND AIRFIELDS

To Osprey enthusiasts in Japan or Scotland it might seem odd that Ospreys and aircraft could ever be a lethal mix. Scattered, remote nesting in those countries means the birds are never likely to encounter a plane. But that is not the case in North America, especially along the US Atlantic coast, where Osprey nesting concentrations abut some of the most densely settled regions in America. Consider Langley Air Force Base, Virginia, a key US military airstrip outside of Washington, DC, perched at the entrance to Chesapeake Bay, a mecca for nesting Ospreys. Pairs quickly adopt the abundant power poles and lighting structures at airfields as nest sites and often gravitate to airport runways as feeding sites, sitting calmly out on these open cement landscapes. Needless to say, all this makes for a potentially deadly combination of bird and plane.

In 2000, an F-15 Strike Eagle fighter jet stationed at Langley collided with an Osprey, killing the bird and causing more than $750,000 (US) in damage to the plane. The pilot was forced into an emergency landing. Between 1990 and 2011, the number of strikes increased dramatically in the United States, from about two or three to more than twenty-five annually, a testimony to the near exponential growth of Osprey populations in areas where large airports are part of the landscape—especially Florida, New York State, and the District of Columbia.

Damage to planes rather than the death of Ospreys was the main concern for most people involved. In a region with hundreds of pairs of nesting Ospreys the loss of three or four individuals is not a major issue, unfortunate as it may be. In the last few years the average cost per Osprey strike has been between $20,000 and $40,000, depending on the aircraft. And as the movie *Sully* shows so dramatically, the potential loss of human life from bird-aircraft strikes could be catastrophic. In three aircraft-Osprey strikes to date, pilots have been injured. Not surprisingly, airport managers have been increasingly motivated to do something, and their efforts have gone in several directions.

Solutions have centered largely on removing “problem nests” (those close to runways) during the nonbreeding season, as well as making such nest sites unusable for the birds (a better long-term solution). Quick fixes have involved the oiling of eggs, so a pair would leave the area sooner rather than lingering on to raise young there, as well as the translocation of young to more distant nests. In addition, reports list a number of management techniques that are described with an interesting slant toward technical jargon—in part, one suspects, to keep Osprey enthusiasts from becoming alarmed: “nonlethal hazing and harassment, installation of perch deterrents on airport structures, possible use of infrasound and audible noise deterrents, pyrotechnics, translocation or removal of problematic individuals." While some of these methods need no translation for the layperson, and seem reasonable, one does wonder at the use of "pyrotechnics" (setting off firecrackers?), audible noise deterrents (loud rock music?), and the "removal" of problematic individuals (shooting?). In fact, there were reports of numerous Ospreys shot by authorities at New York City airports, at least for a few years in the 1990s and early 2000s, before cooler heads prevailed and some of the deterrent methods listed above proved effective enough to alleviate the problem.

In many ways I worry more about Ospreys nesting near busy highways. Every year in the salt marsh colonies I study near my home in coastal Massachusetts we lose two or three individuals to collisions with cars or trucks on nearby roads. Windy days seem to be the worst, with birds often struggling to carry large sticks or fish back to their nests. Those situations find the Ospreys flying low and laboriously, a lethal combination when trying to get up and over a busy road. Data from bird rehabilitation centers show that collisions with vehicles are the leading causes of injury to the Ospreys they receive. It's likely that for every road-injured Osprey brought in their doors there are at least three or four others that were killed and never found.

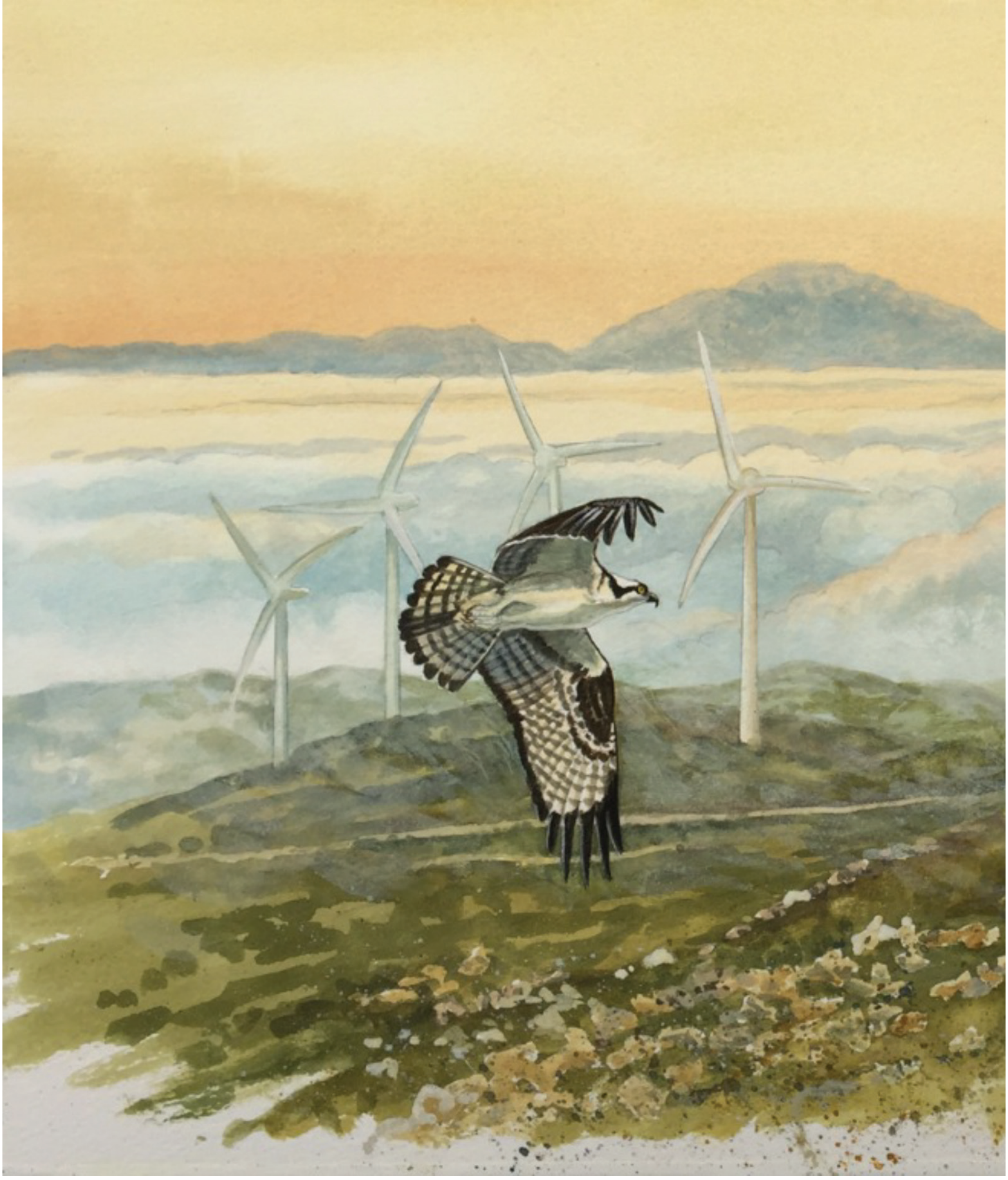
WIND TURBINES: A GREEN THREAT?

In July 2016, my telephone rang and a birding friend gave me a sad update on one of the many Osprey nests in my neighborhood. The male at a nearby nest had been found dead on the ground near one of the large wind turbines in our area. The fish it was carrying was beside the bird, slowly decomposing. The story was clear: lugging a fish back to his nest, that Osprey had failed to make it through the slow-turning blades. Two years before, the same thing had happened at this same location, so this was not an isolated occurrence.

Twenty years ago I never had to worry about such things. Wind power was a distant dream for most people, and there were certainly no turbines where I lived. Today, new turbines are being installed at an almost exponential rate. Around the globe, power generated by wind increased from about 17,000 megawatts in the year 2000 to 433,000 megawatts in 2015, with much of this happening in western Europe, close to Osprey migration paths.

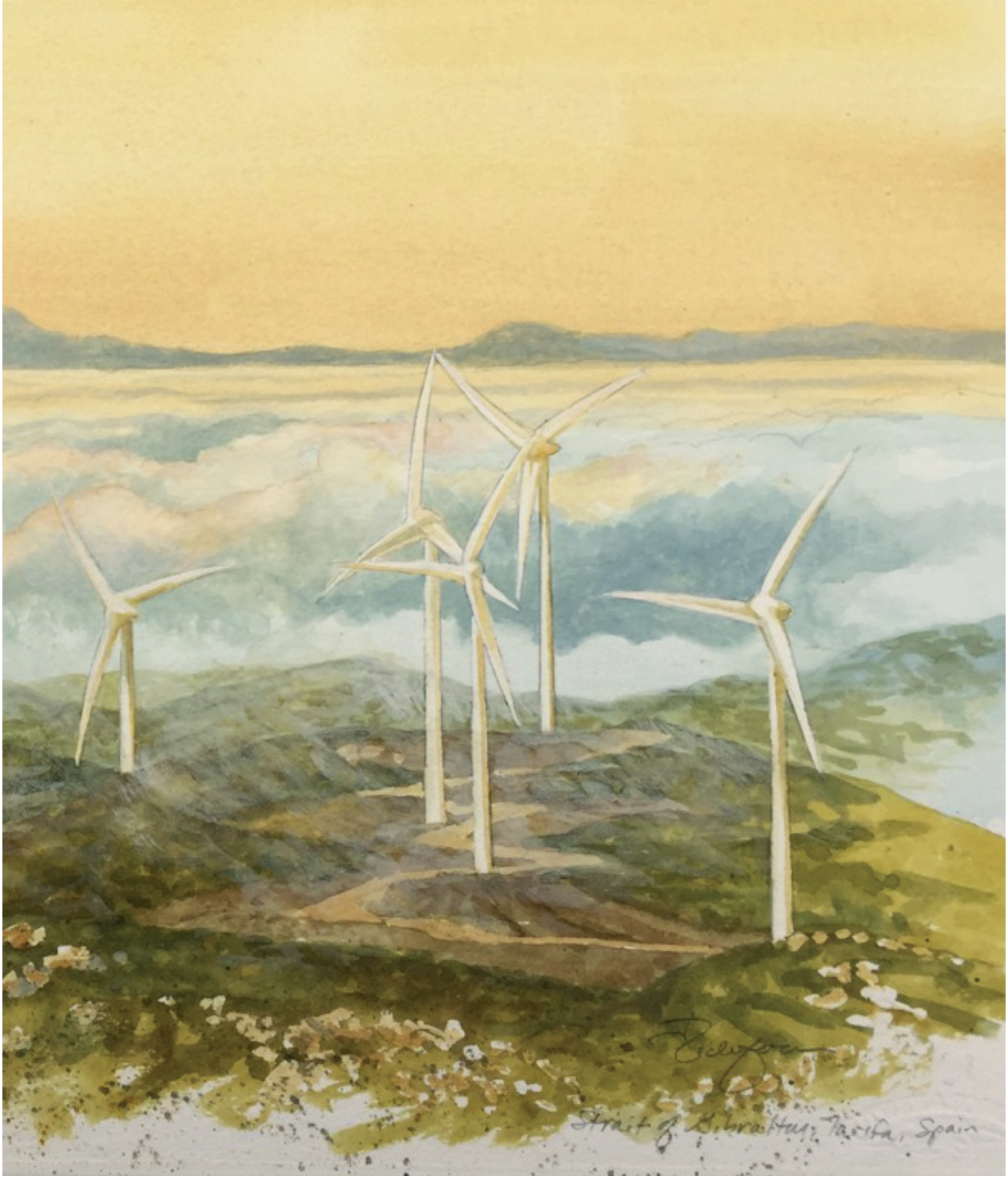
Although the data are few, it seems fair to say at this point that Ospreys are not seriously threatened by wind turbines, even though a handful die each year in the turning blades. But as we look ahead, that picture could change. Much hinges on where the turbines are sited. Controversial clusters of turbines have sprung up in recent years near hawk migration concentration points in southern Spain and Mexico. We know of no Ospreys killed there yet, but as these clusters grow so does our worry. One of the newest areas for offshore wind power is along the US eastern (Atlantic) coast—an important corridor for Ospreys migrating

Do wind turbines pose a significant hazard to Ospreys? We have no definitive answer, but concentrated wind farms along key migration routes—like this one in southern Spain—are clearly a worry.



south each fall. I have particular concern for individuals migrating at night, or in weather when visibility is low. Without consistent monitoring, which is rarely attempted and impossible to achieve at offshore facilities, it will be difficult to know what the turbines' toll will be.

One encouraging note: the number of raptor fatalities declined substantially at a wind farm in northern California when older and smaller low-capacity turbines were replaced with taller high-capacity ones. Large turbines turn more slowly, which may be partly responsible for the decline in bird collision rates. Most

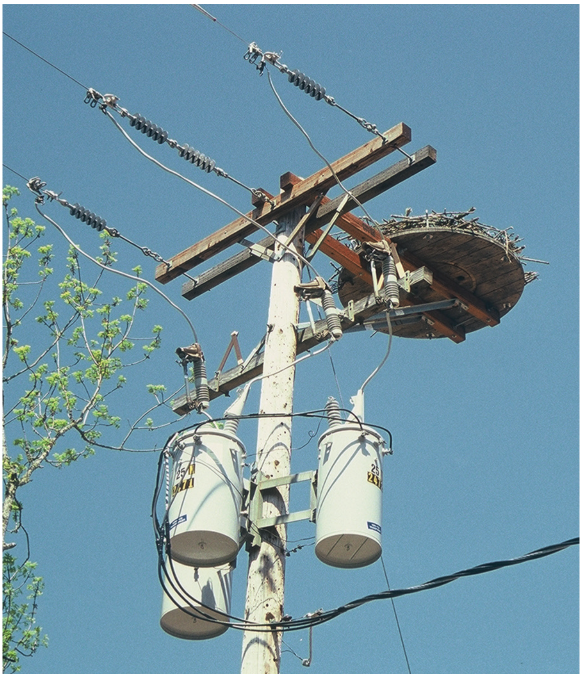

Strait of Gibraltar, Tarifa, Spain

of the new turbines now installed around the world are these taller high-capacity machines, so for bird conservationists there is some reason for optimism. In addition, at facilities where bird strikes continue to be an issue, it is often possible to shut down the turbines during peak migration weeks, given pressures from government and conservation groups. All in all, continued monitoring is clearly warranted, and we can hope that clean energy and Ospreys can move into the future on a sustainable path together.

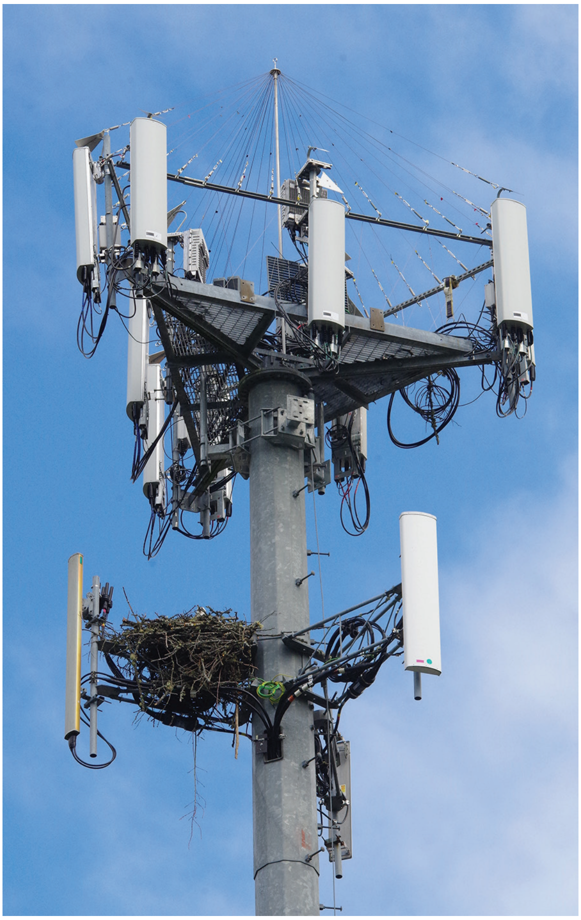
PROBLEM NESTS: POWER LINES, COMMUNICATION TOWERS, CHANNEL MARKERS

Hire a small plane and fly low along the major electrical power lines of northern Germany. Drive highways through eastern and central Florida, keeping an eye out for the huge metal towers that now dot that landscape, supporting cell phone and other communication arrays. Keep careful watch on channel markers as you sail a boat up the Atlantic Intracoastal Waterway, that 3,000-mile (4,800 km) coastal stretch of canals and saltwater sounds that can carry a boat from Massachusetts to Texas without having to once brave the open sea. The common thread linking all these sites is nests, Osprey nests, often enormous ones. As we've seen, nesting Ospreys are not shy about adopting the odd and growing array of structures that humans have built along our waterways. In fact, nearly 80% of US Osprey nests today are resting on some form of artificial structure, most of them designed for something far different than a nesting Osprey. So an Osprey's vision of how these structures can be useful often clashes with what humans have in mind for them.

We should begin by pointing out that in the complex cost-benefit equation of the human-Osprey relationship, the part that revolves around best use of artificial nesting structures shows Ospreys clearly ahead. In Florida, for example, a rough estimate of the number of nests on cell towers alone is one thousand, about 20% of that state's total Osprey population. As each tower costs about $250,000



This power pole in Oregon has been modified to accommodate nesting Ospreys, with the nest kept well away from the electrical lines.



Communications towers are ideal nest sites for Ospreys, with several thousand pairs using them each year in the United States alone. Conflicts arise when the nests short out equipment. Note the tent of wires atop this tower, installed to keep Ospreys away from areas where they are most likely to cause trouble, and how these Ospreys have managed to circumvent this deterrent by nesting on supports underneath.

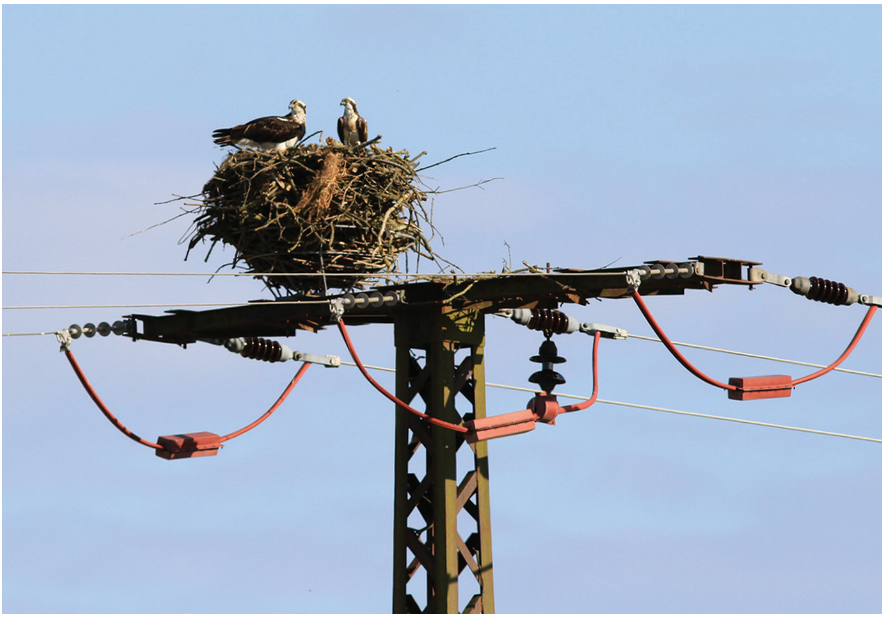
(US) to build, that's almost a quarter of a billion dollars' worth of human structures that Ospreys have appropriated. Not bad for a lowly bird!

On Chesapeake Bay the numbers are equally impressive. At least two-thirds of the over nine thousand nests are on overwater structures that help guide boats: channel markers with numbers (and some with lights), built and maintained by the US Coast Guard. So here we have almost 15% of the world's Ospreys living off the largess of a US government agency. And in Germany, as we've seen, about half of that country's six hundred or so nests are built atop power pylons—those enormous steel towers that carry electrical transmission lines. Here again we see a bird showing extraordinary adaptability, moving in as the uninvited guests of power companies, which seem willing to put up with them, rent-free. How do the Ospreys get away with all this?

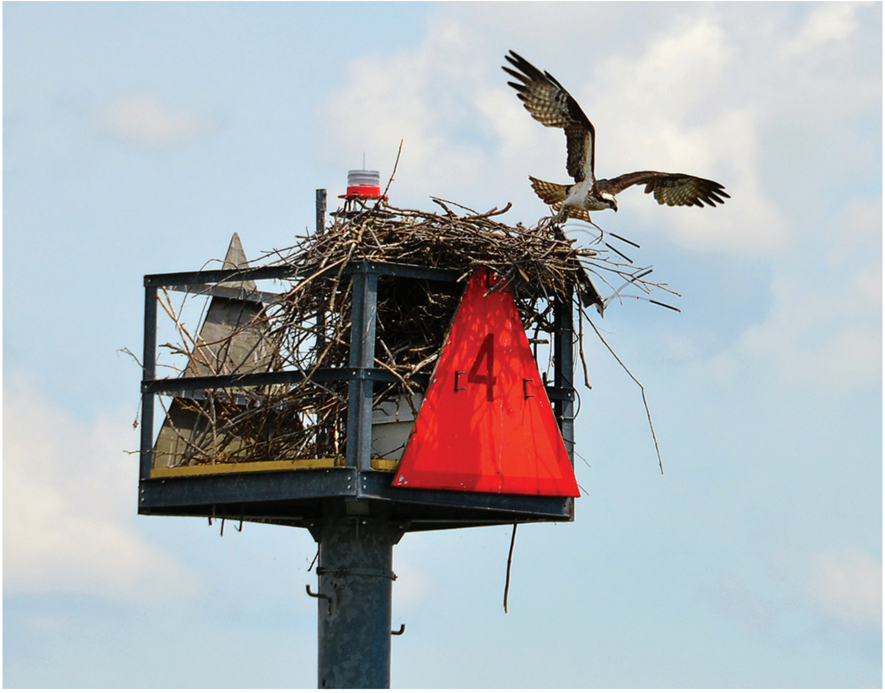
The short answer is that they are, on the whole, well-behaved guests. With some notable exceptions, Ospreys and their nests have little impact on the structures that support them, or on how those structures function. Many of those German nests are atop the tallest parts of the pylons, well away from the business end of those structures—the cross arms that carry the electrical lines. And where nests are closer to lines, risking electrocution of Ospreys or shorting out power, German researchers, in cooperation with power companies, have built supports that keep nests well away from the megavolt lines nearby. Similar efforts are underway in other parts of the world, especially the American West, where much effort has been devoted to keeping birds of prey from getting killed on electrical lines.

Conflicts are perhaps most conspicuous in the eastern United States, where burgeoning Osprey nesting populations often overwhelm electric companies that are ill prepared to deal with them. On Cape Cod, Massachusetts, for example, I see Ospreys time and again trying to nest on roadside power poles, only to have the local power company rip out the nest and set up deterrents to keep the pair from coming back. But often the birds just move down the line and start to build again on another pole, so the battle continues. Without coordinated efforts to modify a pole for safe nesting, or to lure the birds to an alternate site away from the power lines, the frustration of dealing with Ospreys hungry for nest sites is likely to continue in many areas. The solution—dealing with the issue on a nest-by-nest basis, and providing safe alternate sites—takes time and money, which power companies often lack or are unwilling to commit. There is a niche here for local specialists to fill, helping to guide the companies to workable solutions and even doing some of the work themselves.

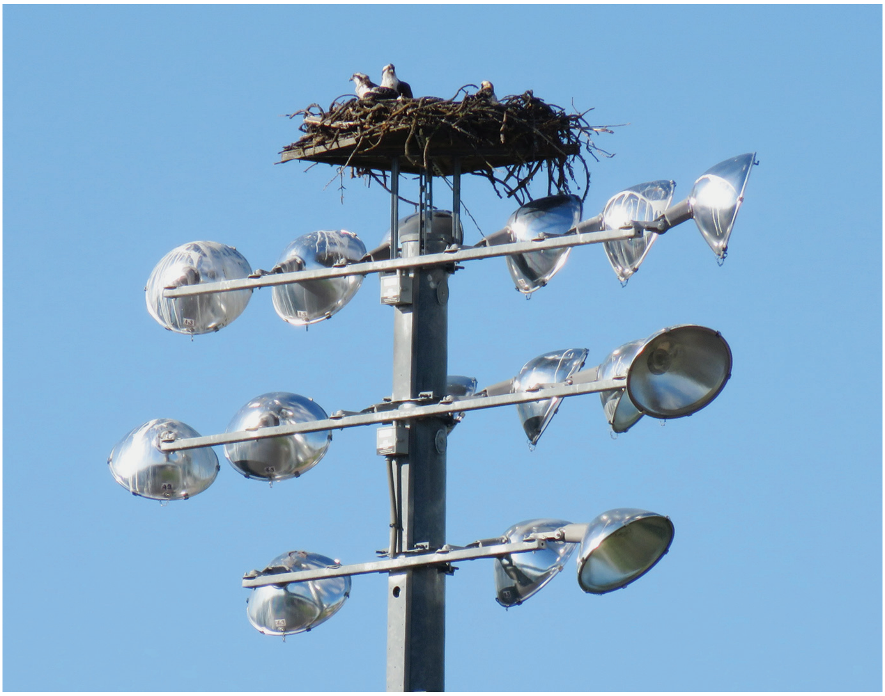
In the case of navigational markers, here again few nests actually interfere with either the lights or markings that are the working parts of these structures. But where nests do become problems, the poles can often be modified to accommodate



This power pylon nest in northern Germany is typical of those that have helped fuel the recovery of nesting Ospreys in that country. Researchers built the basket seen here to help support the nest atop this structure, keeping the birds away from dangerous electrical lines below.



Channel markers are ideal nest sites for Ospreys along many waterways in the United States, providing a solid base, a nest-friendly top, and overwater protection from predators. Conflicts arise when a nest grows so big that it obscures a marker's numbers or lights. Chesapeake Bay, USA.



Lighting structures often attract nesting Ospreys. Here we see how one such structure has been modified to accommodate the nesting birds. Oregon, USA.

Jim Kaiser

OSPREY SOLUTIONS, LLC

When searching for ways to measure the success of breeding Ospreys in North America, we need look no farther than Jim Kaiser's Osprey Solutions, LLC. Jim is a raptor biologist in the Pacific Northwest whose studies there showed him rapidly growing numbers of Osprey nests in problem locations—for example, on electrical poles and cell towers—as well as an alarming number of Ospreys electrocuted on power lines. Jim decided these were issues that demanded solutions, and that there was a viable business in doing that. So was born Osprey Solutions, LLC.

Jim's childhood was spent in the midwestern United States, in southern Indiana, where a growing interest in Ospreys was kindled by occasional sightings of individuals migrating through that state, at a time when the species was rare there and not known to breed. As a student at Indiana University, Jim went on to compile an extensive database of Osprey and Bald Eagle life history information and raptor reintroduction techniques while completing a wildlife management degree—studies that proved useful when Indiana began reintroduction programs for these two species a few years later.

After college, in the mid-1980s, Jim moved to Long Island, New York, for work on coastal water birds, and there was given the chance to assist with an annual nesting survey of Ospreys in that region, a long-running project organized by the New York State Department of Environmental Conservation. Jim recalls the thrill of that trip: "sitting in the open door of a helicopter, held in by a restraint belt and feet dangling, while hovering at tree-top level to count nestlings at nearly 200 nest sites over a two-day period. . . . I was hooked!" He went on to other Osprey surveys and to take a position with Drs. C. J. Henny and Robert Grove of the US Fish and Wildlife Service in the Pacific Northwest, investigating the effects of environmental contaminants on several large Osprey populations in that area over a twenty-two-year period.

While involved in this work, Jim visited a lot of nests on power poles (the kind with live wires!) and began to notice that while many of the poles were retrofitted with alternate nesting platforms to reduce the risk of electrical outages the nests might cause, few were modified to reduce the risk of electrocuting Ospreys. With funding from the Edison Electric Institute in Washington, DC, Jim initiated a multiyear field assessment of nest management practices and electrocution rates at 171 Osprey nests built on power poles in the Willamette Valley, Oregon, and worked directly with local utility companies to help make these nest sites safer for birds of prey. These findings were compiled and suggestions for improved nest management strategies were shared widely with other electric companies.

A surprising finding from Jim's assessment of electrocutions was that for every Osprey carcass found and reported, fifteen went undetected. Scavengers took the rest. So it appeared that Ospreys were getting electrocuted far more often than people had realized and this motivated Jim to launch Osprey Solutions. His goal with this venture has been to prevent the conflicts that arise when Ospreys and other raptors nest on transmission towers, cell towers, and light poles, and he has done this by helping to develop cost-effective, lightweight, and durable nest excluders that are easy to mount and retract.

His clients have included one of the largest manufacturers of outdoor sports lights (Ospreys love to nest on outdoor lights), one of the largest US cell-tower companies and their wireless telecommunication tenants, and several electric utilities throughout the United States and Canada. Jim's nest management strategy is based on lessons learned from the electric power industry: to voluntarily accommodate displaced Ospreys with a safe, alternate nesting structure, if possible, after removing the nest at the end of the breeding season and installing antinesting devices. The results are a win-win for Ospreys and humans: the birds get a new nest site, well away from dangerous power lines, and the electric companies have to answer less often to irate customers wanting their power back after a nest has shorted it out.

Jim is part of a long tradition. The practice of accommodating Ospreys with a safe, alternate nesting structure dates back to at least the early 1900s when cartwheels were attached to the top of poles to lure Ospreys away from nesting on telegraph poles. But today this is a viable business, at least for one company, and I'm willing to predict that others will follow in the footsteps of Jim Kaiser and Osprey Solutions.

both nests and lights. In more extreme cases, the nests can be removed and the structures reworked to discourage future nesting. All this can be expensive, so work often gets put off and conflicts do arise. But this happens seldom enough, so far, that most Ospreys seem not to have worn out their welcome.

Many nests on navigation markers get watched over by their human neighbors and gain protection that way. Cell-tower nests, not surprisingly, have fewer local guardians, given that most are 100–200 feet (30–60 m) high, at the tops of the towers, and well beyond the notice of all but the keenest birders below. The number of these towers has grown exponentially over the past two decades, with hundreds of thousands now scattered across landscapes in Europe and North America. Little did the designers of these towers know, but they created structures with almost ideal characteristics for nesting Ospreys: a flat work platform at the top, large enough to accommodate a big stick nest; multiple perches for roosting; and commanding height. Conflicts arise when Osprey nest materials interfere with the transmitting equipment on the towers, interrupting service, or when repairs and maintenance must be completed. But increasingly those conflicts are being resolved by efforts to build nesting deterrents on the towers, or by adding side platforms attached to the towers to accommodate the nests away from the critical parts of the transmitters.

CONTAMINANTS

While five decades ago an Osprey book could easily have devoted an entire chapter to the threat of environmental contaminants—numerous populations were that severely impacted—today we can relax a bit. The urgency of the topic has diminished, at least as far as Ospreys go—although recent data show that global production of “active pesticide ingredients” topped one billion pounds (ca. 450,000,000 kg) annually, and that number continues to climb, with new chemicals added to the mix each year. So it pays to stay wary. Ospreys can help us in this regard, serving as an important barometer of the levels and kinds of contaminants in aquatic food webs. Pulling one egg from a handful of nests or a small sample of blood from a few young before they fledge can, once analyzed, tell us a lot about what is in the water and in the fish these birds depend on, while having a negligible impact on individuals or populations. Keep in mind we eat some of the same fish that Ospreys do, out of the same waters, so this is more than just a study of wildlife health. Ospreys and humans are both apex predators, vulnerable to the same build-up of contaminants in food webs. Knowing what is in Osprey blood may tell us a lot about what is in our own.

Of all the environmental contaminants that hit Ospreys, the compound DDE, formed by the breakdown of DDT in the environment, had by far the most devastating effects. Its impacts were specific: as a fat-soluble compound in food chains, it concentrated at each higher level; and reaching Ospreys at the top of that chain it interfered with the physiology of eggshell formation in females. Consequently, eggs were laid with thin shells and often failed to hatch; year after year populations struggled to gain new recruits. In addition, evidence suggests that DDE killed embryos and very likely adults as well.

But one thing that helped save Ospreys in impacted areas was the longevity of these birds. With a potential lifespan of over twenty years, some Ospreys were able to outlive DDT, especially as spraying in many areas was sporadic and almost never lasted the full period that the pesticide was on the market. In addition, looking back to that era we now see that some local populations continued to produce at least a few young, and in other areas DDT use stopped early, well before it did in others, putting nests back into production while neighboring populations continued to struggle. All this helps to explain why no North American Osprey population went extinct during the pesticides era, even though a few came close.

What seems remarkable now about this story is how quickly populations recovered. Once DDT use dwindled in the mid- to late 1960s, Osprey young started popping up in nests less than a decade later. I first began checking Osprey nests along the coast of southern New England in 1974, and I still vividly remember the excitement of climbing to nests in trees, or getting lifted to nests on power poles by the hydraulic arm of an electric company's bucket truck. Although many nests were still failing then, and I'd occasionally find desiccated, broken-shelled eggs, time and again I'd come up over the lip of a nest to see the wobbling heads of young. Ten or even five years before that, many of those nests would have been empty. Such was the power of microbes to unravel DDT molecules in water, and the power of sediments to bury them. That combination helped release Ospreys into a new era, and we all have been lucky enough to be part of it.

Small pockets of contamination remained into the 1990s in the western United States (lower Columbia River, Oregon) and along the East Coast's Delaware Bay, both of which drain large agricultural and industrial areas, but none of these hot spots was large or lethal enough to have kept those populations from rebounding. In Chesapeake Bay, levels of most pesticide contaminants measured in the late 1980s were less than half those seen ten to twenty years before that, and that picture was typical for nearly all other US Osprey habitats. Studies have continued to track chlorinated hydrocarbon contaminants in North America, especially in Oregon and Washington, finding levels generally well below those known to affect breeding success.

One study followed satellite-tagged Ospreys from this region to their wintering grounds in Mexico and Central America, comparing contaminants in fish from the two areas. With few exceptions, the tropical fish were cleaner than those sampled on nesting grounds, suggesting that levels measured in Oregon eggs reflected what females acquired after they were back at nests. In fact we know that

Ospreys produce eggs not on body reserves they store on wintering grounds but on the day-to-day intake of fish once they arrive back on breeding grounds.

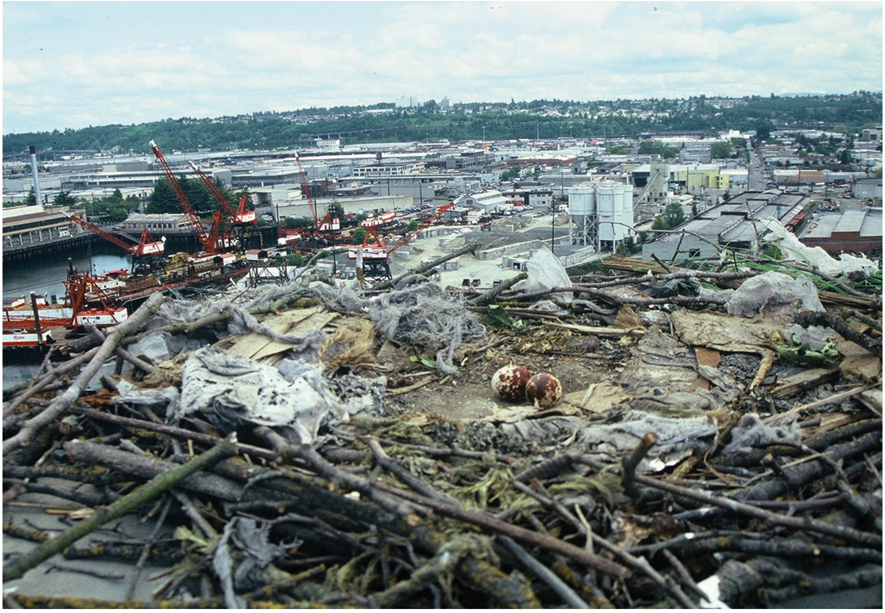
While pesticides have gotten much of the attention in Osprey contaminant studies, heavy metals (especially mercury) have also generated concern. Mercury is toxic and often leaks into rivers and lakes from mining operations, as well as being spewed into the atmosphere by coal-fired power plants. So it is a widespread pollutant, especially in freshwater habitats. Fish concentrate it and birds do too, although in birds much of the mercury in the body gets deposited in feathers when these are grown at the time of annual molt, so it's less likely to build up in blood and tissue. Even so, bird eggs (embryos) are very sensitive to this toxin and lab studies suggest that Ospreys are at the high end of this sensitivity. But the jury is still out on Ospreys and mercury, especially at the population level. A few Montana Ospreys nesting along polluted rivers may have been compromised in some years, but overall these birds are thriving, as are most of those in other areas showing elevated levels of mercury in eggs.

A worrisome trend is the development and release of a host of new industrial pollutants, most of which fly largely under our radar. Take the polybrominated diphenyl ethers—flame retardants used widely in bedding and clothing, the things we put next to our skin day in and day out and rarely think about. But these compounds are now widespread in the environment and are found in Osprey eggs and blood throughout North America, and probably globally. Impacts on birds have yet to be shown, but it is troubling to see the reach of such new contaminants and to know they are working their way through aquatic food webs, just as they are through our own bodies.

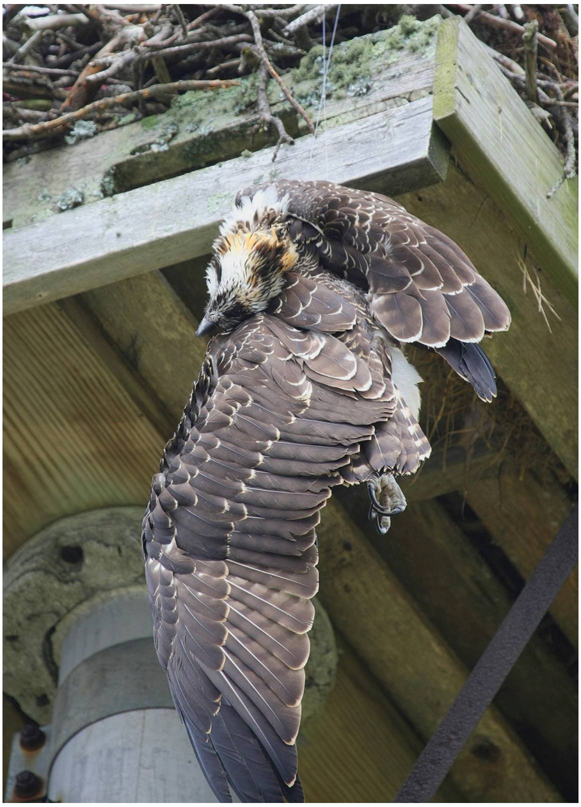
If there is a lesson to be learned from all this it is easily summarized: be wary. No one could have predicted the heavy impact that DDT would have on Ospreys and other birds of prey. Although Ospreys have recovered from that scare in surprisingly robust form, there are a lot of new contaminants being thrown at them each year. If we agree, as western US Osprey researcher C. J. Henny has suggested, that Ospreys are an ideal sentinel species, then we will continue to keep an eye on these birds, setting up protocols for sampling eggs and blood in nests around the globe. Doing so will let us keep a finger on the pulse of the ecosystems that support Ospreys—and ourselves.

LINE, TWINE, AND PLASTICS

In the eighty or so Osprey nests my colleagues and I study each year in southeastern Massachusetts, we often find tangles of discarded fishing line, as well as lengths of frayed rope and twine. There's something about this material that seems to have a magical attraction to a nesting Osprey. Once incorporated into the nest, these tangles often turn out to be surprisingly hazardous, particularly as the nestlings become mobile and start to wander the nest. Despite our best efforts to



An Osprey nest on the edge of an industrial park in Seattle, Washington, USA. Here we see how readily the species adapts to human landscapes. Note how much plastic has been incorporated into this nest.



This fledgling Massachusetts Osprey was killed after becoming entangled in discarded fishing line that its parents had brought to the nest. Such deaths are rare but regular in areas where Ospreys and fishermen overlap.

clear nests of these tangles, each summer we find a few fledglings with a leg or wing wrapped in line, sometimes constricted enough to have cut into flesh (or rarely amputating the limb) and almost always keeping the bird tethered and barely able to feed. Without our rescue, these young would surely die.

In midwestern and western North America, discarded twine from hay bales gets scattered around in fields and nest-building Ospreys often pick it up. Over a period of five years, almost 12% of seventy-seven Ospreys banded at nests in west-central Saskatchewan, Canada, were found entangled in baler twine, many with injuries that clearly compromised survival. At one nest the desiccated body of an adult was found dangling below the nest, a long strand of baler twine around its neck. Similar problems have arisen in Montana, with Ospreys breeding near agricultural fields almost always incorporating baler twine into their nests, sometimes massive amounts (one downed nest contained over one-quarter mile [0.4 km]), with 5%–10% of young each year found entangled and half of those dead. Even in productive populations, losing 10% of the young each year is significant, and the problem shows little sign of going away quickly.

Plastic bags and wrappings are another form of human throwaways that Ospreys like to put in their nests. They seem attracted to these for the same reason they like pieces of cardboard and flat mats of seaweed and algae. Males switch to material like this as nest-building progresses and they begin to look for lining material to keep eggs from slipping into the spaces between sticks and branches. Flat plastic seems ready-made to fit that search image. But such plastic can smother eggs and small chicks; every year we lose young to such tragedies, even though we routinely pull plastic from nests during our surveys. For those seeking to ban throwaway plastics, Ospreys can serve as exhibit A in the pantheon of wildlife species that would benefit.

PREDATORS

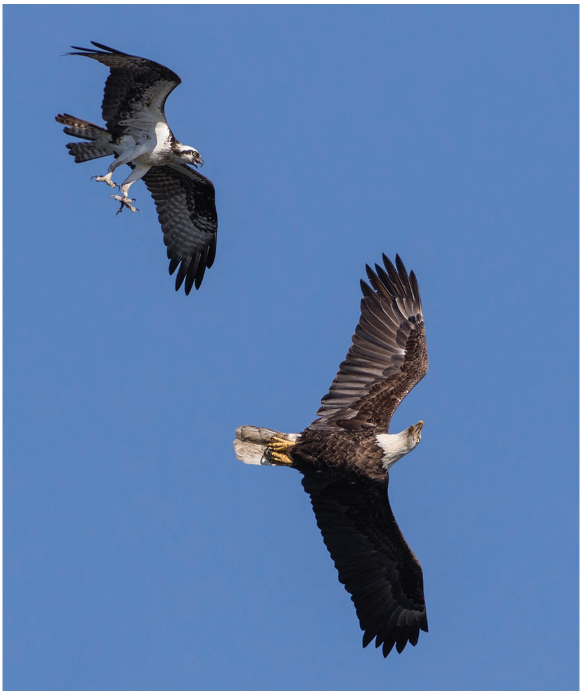
Although our focus in this chapter is on threats that humans have imposed on Ospreys, it's worth considering at least one natural threat—predation—in part because doing so sheds light on interesting aspects of the ecology and behavior of our bird. Ospreys have almost certainly been dealing with predators since they evolved, although we can only guess at what they were up against 500,000 or even 1,000 years ago. But then as now we can be sure that large size and agile flight give adults protection against many animals that might come after them. Exceptions are some of the large owls (in the Northern Hemisphere, those in the genus *Bubo*—Great Horned Owl [*B. virginianus*] in North America and the Eurasian Eagle-Owl [*B. bubo*] in Europe and Asia). These formidable predators, as big or bigger than Ospreys, have the advantage of quiet flight and nighttime stealth, and have been strongly suspected of killing adult Ospreys at the nest and at roosts in migration, although nestlings are far more vulnerable.

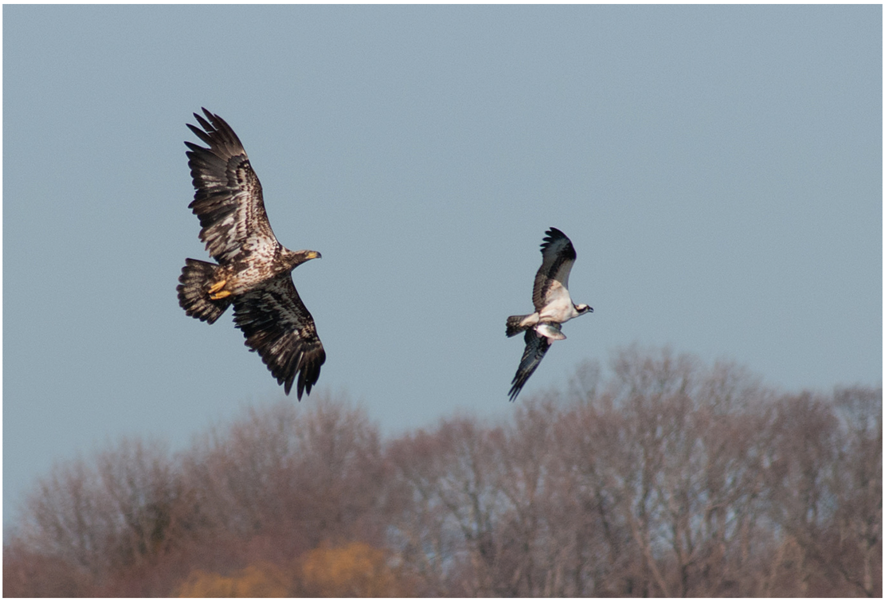
Indeed, Osprey eggs and young are most likely to fall victim to predators. That said, daytime predators at nests are often kept at bay by the very real threat an adult Osprey can present to a climbing mammal or a marauding gull or hawk. Or even a human. I very nearly lost an eye to a female Osprey protecting its nest. Climbing a nest tree and foolishly poking my head above the nest-supporting branches, I was suddenly slammed from the side by what felt like a powerful fist, and then sliced by a claw that left my face so bloodied I could barely see. It was a one-two punch; hit first by the balled knuckles of the front three claws as the bird dove hard and fast at me, and then ripped by the open hind claw raking across my face. Climbing down from that tree was the longest five minutes of my life. Had I been a raccoon or a marten (*Martes* species), both potential predators of Osprey nestlings, I doubt I would have lived.

Both male and female Ospreys defend nests, although females—perhaps owing to their larger body size—tend to be more aggressive. But it is fascinating to see, even within the sexes, to what extent individual Ospreys differ in the vigor they bring to nest defense. Out of twenty nests I might survey in an afternoon along our New England salt marshes, one or two will have females so aggressive I have to avoid them altogether. At one or two others, the adults disappear entirely, or circle at a distance, when I approach, clearly intimidated by my presence. Most pairs are somewhere in between, diving at me as I come up to the nest and look into it, but never coming close enough to really threaten me. If defense against humans reflects what nonhuman predators can expect to encounter at Osprey nests, then it's clear some nests will be far more vulnerable than others.

It is the big burly *Haliaeetus* eagles that may pose the biggest threats to Ospreys, however. With eight species globally, about half of which overlap with Ospreys in their preference for aquatic habitats, these eagles are well known to be determined pirates of fishing Ospreys, robbing them of their prey in dramatic, twisting aerial pursuits. But the eagles also snatch young from nests. Along the coast of Maine, nest cams have helped reveal that resurgent populations of Bald Eagles (*H. leucocephalus*) are beginning to kill increasing numbers of Osprey young, including large young close to fledging. Nevertheless, the population impacts, so far, appear to be minimal—overall breeding success remains robust there. Likewise in Chesapeake Bay, where enormous populations of Bald Eagles and Ospreys share estuarine habitat (ca. two thousand pairs of eagles, and over nine thousand of Ospreys), careful studies by Bryan Watts and colleagues show that Osprey reproduction hasn't suffered there either, with the Ospreys thriving in areas they share with eagles and even taking over key portions of coastal habitat that once held eagle nests.

By watching areas where the two species interact, we can begin to understand how this might happen, how Ospreys might emerge the winners despite the eagles' size and power advantage. For Ospreys sharing a habitat with *Haliaeetus*





Top: Ospreys can be very effective at harassing eagles (here, an adult Bald Eagle) that come near their nests, especially when multiple Ospreys join the chase. *Bottom:* Ospreys carrying fish are known to lose their prey to eagles that pursue them. This immature Bald Eagle is making a determined effort to snag a free meal. Connecticut, USA.

eagles, it seems there is safety in numbers. Especially in areas where Ospreys nest densely, the appearance of a Bald Eagle will often scramble defending male Ospreys like fighter jets. Two or three harassing Ospreys are usually enough to send any eagle off in search of calmer skies. Lone Osprey nests appear to be more vulnerable. A determined eagle can wear down the parents and keep a sharp eye out for the right moment to launch a sneak attack and grab a chick.

We should keep in mind that Ospreys and *Haliaeetus* eagles have been co-evolving for millions of years, so there's no reason to think that the two species won't continue to strike a balance, even in areas where eagle populations are rebounding. In Japan, studies suggest that regions with the highest densities of eagles have the lowest densities of Ospreys, hinting that avoidance may be one part of the Osprey strategy. In Florida, Bald Eagles moving into an Osprey neighborhood seemed to discourage nearby nesting for a year or two, but then the Ospreys resettled old nests and coexistence resumed. So overall, while eagles may be formidable pirates and predators of some Ospreys, even killing young at nests, it does not appear that we need to worry about them having major impacts on our famed bird.

HUMAN DISTURBANCE AND HABITAT CHANGE

Over a hundred years ago the British naturalist and Osprey enthusiast C. G. Abbot sailed the Atlantic from England and made a quick tour of Ospreys and their habitats along the East Coast of the United States. He was struck by the contrast between what he had left behind and what he found when he landed: "I had often read of the lonely Osprey tenants of one or two silent Scottish lochs, with the watchful eye of a warden constantly upon them, and my surprise can therefore be imagined when I saw my first American Osprey nest. It was at a popular seaside resort in New Jersey, and perched in a tree overlooking a lake full of row boats and noisy holiday-makers."

In the summer of 2016 I made a pilgrimage in the opposite direction, visiting fellow Osprey researchers in Scotland, France, and Finland. And in many ways my experience was the mirror image of Abbot's. I had left behind neighborhood nests that included one on the floodlights of a high school baseball field, several on power poles along busy highways, and more than seventy atop nest platforms in the middle of a tidal river, a river that hosted hundreds of boaters every summer weekend. Arriving in Scotland was like stepping back in time. Osprey nests there were mostly hidden away in deep forests, often on large estates, where the birds rarely saw a human. A few of the Scottish pairs had moved out into farm fields and pastures, nesting in big trees along hedgerows and thus a little more exposed to human activity, but here again disturbance was rare. And my colleagues there were taking great pains to protect all nesting pairs from intrusions, with nest locations kept hidden from the public and, failing that, posted signs warning people away. It was much the same picture in France and Finland.

Looking back on that visit, it seemed at times as if I were seeing a different bird than the one I knew from home. Of course those Ospreys were all the same species and behaved much the same in their nesting lives, although the European birds were warier. What did differ were the cultures and landscapes that shaped the species in each location. Colonizing areas with dense human populations, Ospreys are clearly showing they have the capacity to habituate to intense levels of disturbance, as mine have done in Massachusetts and as thousands of others are doing across the Americas. Think of an Osprey that winters in remote regions of the Amazon basin, likely going four or five months rarely seeing a human, and then, in two or three weeks, flies back to its nest on the edge of an industrial park in New Jersey—with floodlights blazing at night, delivery trucks coming and going by day, and the clang of a pile driver building new docks close by. Yet that Osprey fresh out of the Amazon will seamlessly settle back at its nest.

Habituation is the key to this adjustment, but it doesn't happen overnight. Where Ospreys are most vulnerable is at nests that are undisturbed for weeks or months and then suddenly are surrounded by activity. One thinks of summer cottages, empty until June when a station wagon drives up and disgorges children, dogs, and lawnmowers. The Ospreys nesting on the edge of all that, trapped with newly hatched young, suddenly have to adjust. Our experience has been that some will abandon nests in those situations. But if that same cottage is busy from the time those birds arrive back, the odds are very good the pair will habituate to the disturbance and raise young successfully.

From a researcher's point of view, what is clear is that brief visits to nests, taken with proper precautions (avoiding extreme heat, cold, and rain), have no long-term impacts on an Osprey's ability to raise young. At various points in my research I've had groups of nests that I checked at least three or four times a week, for weeks in a row. The Ospreys quickly adjusted to my intrusions, begrudgingly making way for me as I arrived with a ladder, and letting me climb up into their nests to take inventory of eggs and young. I was generally gone in minutes and the parents were back on their nests soon after that. Studies later confirmed what my instincts were telling me: in a comparison of nests visited often versus those rarely touched, there was no measureable difference in breeding success.

For many threatened bird species, changes on a landscape level, especially loss of habitat, are critical threats. Ospreys seem to be different, more resistant to habitat degradation and less likely to go into decline as humans take a toll on supporting ecosystems. The key to this resilience, of course, is adaptability. With food and nest sites the critical limiting factors in their lives, Ospreys have shown time and again that they can escape being locked into a single track. As nesting trees dwindled in much of the United States, for instance, Ospreys quickly (in just three or four decades) moved over en masse to artificial nest sites. In parts of Europe where these birds still rely on large nesting trees, a dwindling resource, Ospreys have found allies in people willing to spend time and effort modifying smaller trees to support nests and working with foresters to save many of the bigger ones with active nests.

With human fisheries taking an ever-increasing proportion of the planet's fish, and fish diversity plummeting as alien species are introduced into waters they don't belong in, out-competing residents, one has to wonder if all this doesn't threaten Ospreys. Surprisingly, there are few examples to suggest that it does, although over the long term there may be more to worry about. As we saw in chapter 4, Ospreys take a remarkable diversity of fish, rarely depending on just a few species. And their ability to commute many miles means they have some flexibility in the waters they fish. In addition, numerous examples suggest that invasive fish may actually benefit Ospreys—trout in Europe, catfish in Chesapeake Bay, and salmon and other stocked fish in the Finger Lakes of western New York State. All these show us fish communities in great flux over the past few decades, but Ospreys managing to thrive nonetheless.

In summary, we have a survivor here. While many Osprey populations have grown exponentially over the past few decades, with others stabilized earlier on, only a handful are worse off than they were fifty years ago. That's a remarkable feat for a wild animal in today's world, and it's a fact worth celebrating. For those inclined to worry, fish farms may hold the greatest threat to Ospreys. But there's a role here for technology transfer; giving farmers the knowledge and resources to install protective netting is a low-cost and effective solution to protecting fish—feeding people and keeping Ospreys safe at the same time. We need to pursue that. Worriers may also spotlight emerging contaminants as a threat, although it's fair to say we now have our finger on the pulse of Osprey health and numbers in ways we never did before. It seems unlikely that a population crash in this species will blindside us again.

EIGHT

Looking Ahead

It's always tenuous predicting the future, but using the past as a guide can help refine our ways of looking ahead, giving us sharper resolution than we'd have by simply gazing into a crystal ball. What are the lessons we've learned about Ospreys in the past fifty years, and what can those tell us about where the species is headed in the next fifty? How can those lessons guide wise decisions that ensure robust populations in the future? Here we review key findings and use those to spotlight what may lie ahead for our famed bird.

The last fifty years have been a golden period for Ospreys—few can argue with that. Yes, a handful of populations continue to struggle, a small number have even declined or died out, but many have seen extraordinary growth in range and numbers in this period, growth unparalleled in nearly any other bird population on the planet. At a time when most long-distance migratory birds are in decline, with a discouraging number of species moving onto threatened and endangered lists, Ospreys join a small group of native birds in native habitats that are thriving despite today's degraded ecosystems and environmental challenges. We think of Chesapeake Bay, struggling to maintain productivity in the face of waters polluted with nutrient overloads, where Osprey numbers have quadrupled over the past forty years—forming the largest concentration of the species on earth. We think of a few Florida lakes, grappling with weed-choked waters, where Ospreys now nest at extraordinarily high densities, hundreds of pairs tucked into just a few miles of shoreline. We think of Scotland and Germany and France where Ospreys, all but gone a generation ago, are a vibrant part of the landscape again. And we think of Oregon rivers and Tennessee reservoirs and Pennsylvania lakes where the picture is much the same—a chorus of Osprey courtship calls welcoming spring in habitats that were empty of the birds a few decades ago.

Why have Ospreys been able to beat the odds? Why are they the lucky ones? The answers boil down to a single word: flexibility—flexibility in where they nest

Table. Size of Selected Osprey Populations, 1975–2010: Number of Active Nests

	1975	1995	2010
United Kingdom	12	110 (817)	245 (123)
Oregon	13	150 (1,054)	285 (90)
Germany	75	290 (287)	550 (90)
S New England	107	790 (638)	1,274 (61)
Finland	450	635 (41)	835 (31)
NW Mexico	810	1,360 (68)	1,350 (−0.7)
Chesapeake Bay	1,500	3,500 (133)	9,000 (157)

Note: Numbers in parentheses indicate % increase from previous measure.

and flexibility in what they eat. Food and nest sites are the two key factors that limit breeding numbers in most birds, and Ospreys are no exception. So to get an idea of why Ospreys are thriving again in so many regions, and where they might be headed, we look first at these two topics.

NESTS

If we think of Ospreys as a phoenix-bird, rising from the ashes of the past, nothing has done more to spring this bird free than its ability to nest on structures built by humans. Overall, a good guess is that at least 50%–60% of the world's Ospreys have found nesting sites on some type of artificial structure, a radical adjustment from the habits of fifty years ago.

In the northeastern United States alone, Maine to New York City, at least 80%–90% of our over three thousand pairs of Osprey raise their young on artificial structures, many on platforms built just for the species. Remove all those structures and you'd likely cut this population in half, probably more. In Chesapeake Bay, as we've seen, an astounding 60%–70% of that region's over nine thousand pairs are nesting atop navigation markers, courtesy of the US Coast Guard. And in Europe, outside of Scandinavia, nearly all Ospreys now depend on some sort of artificial nest, either built on a human-made structure or bolstered by a platform in a tree. Are we making our Ospreys "prisoners of platforms," as my Finnish colleague, Pertti Saurola, likes to say?

Perhaps we are, but there are good reasons for this. For one thing, in most areas the large trees nesting Ospreys once depended on are sadly diminished, with modern forestry and "clean farming" practices each taking a toll. In addition, many historically scarce predators have returned in force, especially animals like raccoons (*Procyon lotor*) in North America that depend on garbage and handouts, but can also be serious predators of Osprey eggs and chicks. Taken together, this means Ospreys now struggle to find safe natural nest sites in which they can raise young.

Navigation lights have proven to be ideal nest sites for Ospreys, especially in the United States. Here we see Ospreys that have managed to build a nest without obstructing the light or the solar recharge panels that keep it going, helping to ensure they will remain welcome guests. Oregon, USA.

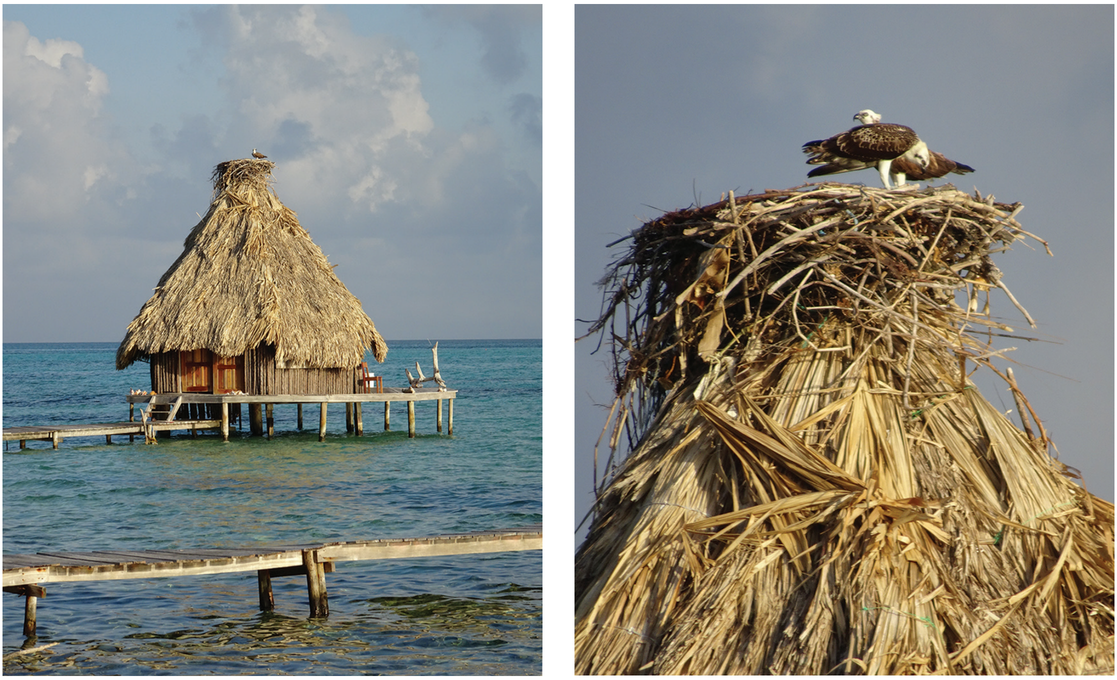
Platforms built in the right locations, and fitted with predator guards, help to alleviate this problem, so in essence we are paying our dues with platforms, compensating for the systematic degradation of Osprey habitats that has taken place on our watch. It seems a small price to pay. The army of Osprey nest site managers is large in this world, and not likely to diminish soon. People derive great pleasure out of rehabbing old Osprey nest sites, or building new ones, in large part because this bird responds so readily to these efforts. Such positive feedback keeps new people coming into the nest management fold, which is a good thing because artificial nests will need continued maintenance in the years ahead.

It is interesting to see the areas where human-made nest sites are a big part of the Osprey picture and areas where they are not, and to think about how this might change. In essence, less-developed regions—such as Canada and Scandinavia and Russia—are those where Ospreys depend most on natural sites. Forests are still relatively intact in these countries and the conservation communities small and scattered enough that nest platform programs have gained traction only locally. Finland, with its well-developed, countrywide Osprey nest-building community, is the exception, but here forestry has taken an especially big toll on nest trees and there is a strong, established, well-organized culture of wildlife management among its citizen-scientists.

Moving to lower latitudes—the Caribbean, Red Sea, Atlantic Island, and Australian populations—Ospreys are also largely on their own for nests, with less than 10% of those birds occupying sites built by humans. Most are cliff and ground or beach nesters, often on islands, so there is less that people need to do to help

Building artificial nests for Ospreys in Finland. Modifying trees to support the nests has been a key management technique in that country and in other parts of Europe.

Over half the Ospreys in Germany nest atop power pylons like this one. Artificial nests are built on these sites to accommodate the breeding pairs.



Ospreys nesting along the coast of Belize and other parts of Caribbean Central America are starting to use thatched-roof cabins as nesting sites. The pairs adapt easily to humans who come and go from these dwellings.

bolster nests. But there is a shift underway in some of these regions, especially Australia, where Ospreys expanding into new regions are taking advantage of emerging human interest in nest platforms. Likewise a few Caribbean Ospreys along the coast of Yucatan, Mexico, are now starting to nest on cell towers and thatched-roof beach cabins, although the bulk of the Caribbean birds still struggle for nest sites. This is a population that is ripe for concerted efforts at nest management. Wildlife tourism helps drive economies in this region and Ospreys nesting on strategically placed platforms could become a significant attraction. But all this takes organization and people-power. It remains to be seen if that can happen in the Caribbean.

Let's not forget that Ospreys can nest in loose colonies when conditions permit, packing a lot of nests into a limited area—a big boost for the species in recovering populations. Nowhere was this more evident than in the great historic breeding colonies along the US East Coast. Colonies were especially evident on the eastern end of Long Island, New York, where beaches and islands held at least four hundred to five hundred pairs, most concentrated into areas of just a few square miles. Clusters of nests were also found on marshes at the mouth of the Connecticut River and surrounding forests, where close to two hundred pairs bred each year up to the 1940s. And in a few New Jersey coastal forests, stunted, storm-killed trees were festooned with Osprey nests. Farther west and north, in Canada and along western US rivers, beaver (*Castor canadensis*) dams created large, shallow flooded areas full of dead trees, magnets for nest-seeking Ospreys.

Although many of these dense historical colonies are gone, with some of those regional populations now just as large but more dispersed, they have been replaced by colonies elsewhere. One thinks of south Florida lakes where hundreds of nesting Ospreys are packed into stretches of shoreline lined with cypress trees, some holding two to three nests each. Similarly, a few New England salt marshes now support dense new nesting colonies, fifty to one hundred pairs in just a few square miles, all on platforms. And there are stretches of power lines in Germany where almost every other pylon is topped with a nest. The key point here is that Ospreys succeed in part because their fish-eating habits mean they do not need to defend large territories; they can tolerate neighbors. So when conditions are optimal—food and nest sites abundant—it benefits not just a handful of Ospreys but potentially dozens or hundreds.

Looking ahead it seems likely that Ospreys in many parts of their range will continue to lean heavily on artificial sites for nesting, especially where humans have cut trees and altered landscapes. And it seems equally likely that humans will continue stepping up to the challenge of providing these sites, and managing the ones that need the most attention. To those who complain that we are making these birds dependent on us, taking away their "wildness," remember that most of our migrant Ospreys are gone for half the year, deep into the wilds of Africa and South America and southern Asia. Platform-nesting Ospreys are still wild birds. We're just lucky enough to be able to live side by side with them while they go about the business of raising their young.

A managed Osprey nesting colony on the salt marshes of southern New England. Nest sites like these, built by local naturalists, are often grouped together, allowing dense breeding colonies to develop. Connecticut, USA.

FISH

If flexibility in choice of nest sites has helped put Ospreys back on the map, and gives every indication of continuing to do so, so has flexibility in diet. As we've seen, Ospreys eat many different fish, even though at any one time and in any one place they're likely to specialize in just a few. Each spring when I see my local New England Ospreys return from tropical wintering grounds, I'm reminded of what an adaptable forager these birds are. The Osprey flying over my house in early April might have been looking for fish in a Cuban reservoir, or along a Bahamian reef, a week earlier. Two weeks before that it was likely hunting fish in the turbid waters of an Amazon river. Different fish, with different ecologies and behavior—yet my neighborhood Ospreys have no problem finding food enough to power flights of a few thousand miles back to their familiar nests. And as soon as these birds touch down here, they head to nearby herring brooks to find those sea-run fish, those locations etched in memory from years before.

But adaptability and good memory are not enough to sustain Ospreys if the fish they depend on are no longer there. The ability of humans to manage fisheries sustainably has proven an elusive goal, to say the least. Those sea-run herring that New England colonists used to harvest in the millions each spring are now a shadow of their former numbers, choked off by overfishing and dammed streams. The trickle that remains is a key resource for Ospreys each spring, and although there are efforts to bring these fish back in greater numbers by opening dams and restricting fisheries, we still have a long way to go before this resource is secure.

Even though we continue to worry about loss of fish, given the reckless abandon with which humans exploit most fisheries, there are few data to suggest that any Osprey population has been seriously threatened by overfishing. While low breeding success and slow population growth has plagued some Osprey populations in regions where fish have been hit hard by humans, we know of no Osprey population that has disappeared because humans wiped out a fishery. Here again, flexibility appears to save the day. With one fish scarce the birds switch to another, often commuting to new waters to find them, even if that involves longer flights.

Chesapeake Bay can serve as exhibit A in this story. Osprey numbers have soared in areas of the Chesapeake where less-harvested freshwater fish thrive, while populations in saltwater portions of the bay have struggled because humans take a toll on fisheries there. A few of these freshwater fish are introduced species, so there as elsewhere we see Ospreys quick to take advantage of a new resource. Introduced fish have proven to be a key part of the Osprey diet in many other parts of the world as well: Scotland and the western US with their ubiquitous rainbow trout, and Africa and Latin America where tilapia often escape from farms into nearby waters.

Female Osprey delivering a flatfish (flounder; *Platichthys stellatus*) to her fledgling at a nest in Oregon.

Small-scale fisheries like this one in Chesapeake Bay, USA, appear to have limited impact on the viability of Osprey populations. Larger-scale industrial fisheries have the potential to do more harm.

Keep in mind too that Ospreys are masters at fishing smaller bodies of water, ponds and streams, where commercial impacts on fisheries tend to be much lower. Netting, especially in European lakes and ponds, is worrisome, not just because Ospreys tangle in those nets but because those fisheries are often hitting key species at key times—early spring, just after ice-out, when Osprey bodies need extra calories to restore depleted resources after long migrations.

Looking ahead, it is tough to say with any certainty where fisheries as trouble spots may emerge for Ospreys. Certainly the proliferation of fish farms is cause for concern; significant efforts will be needed to keep Ospreys from dying in increasingly large numbers at those facilities. And it is hard not to worry about burgeoning human populations in West Africa, especially in the Sahel, where drought and overnetting endanger fish in the critical wetlands that Ospreys depend on as they emerge from their long migration over the Sahara Desert. Likewise, we need to keep an eye on the coastline of West Africa, where Ospreys concentrate in winter. There, industrial Chinese fishing boats are fast gaining access to near-shore waters, vacuuming up coastal resources in ways that indigenous, small-scale fisheries never did. Mullet, such an important part of the Osprey diet there, are particularly vulnerable to this kind of intensive fishing since they swim in large schools that are easily targeted.

CONTAMINANTS

If we have to look hard for an Osprey population constrained today by food shortages, the same can be said about populations suffering from contaminants. Clearly that was not the case sixty to seventy years ago, when Ospreys had to confront DDT and other chlorinated hydrocarbon insecticides globally. Most populations, as we've seen, emerged from this crisis with just enough surviving members to stage their remarkable comebacks. Since then, studies have shown lingering traces of contaminants in Osprey eggs and tissues but almost always at low enough levels that neither breeding success nor adult survival were jeopardized. The emergence of new contaminants like the poly-brominated flame-retardants is concerning, but so far the effects of these on Ospreys appear to be minimal, although at higher levels or in newer forms one worries that they could become a more lethal mix.

The good news is that Ospreys can help us track the build-up of these and other contaminants in our environment. We look to a future where this bird will gain increased stature as a "sentinel species," but getting there will take organization and funding. So far, efforts have been focused on the United States, primarily in the West, but Europe has the resources to pick up the next leg of this research, as do Japan and Australia. Only in this way will we have the full global picture that's needed if we are to trace the spread of contaminants in our air and water.

CHARISMA: THE FLAGSHIP SPECIES

Here's a question I sometimes ask myself: if DDT and other pesticides had impacted smaller, lesser-known birds than Ospreys—let's say a thrush, or a rail, or a nuthatch—as seriously as they impacted Ospreys, would we have been as quick to recognize its dangers and rein them in? I doubt it. Yes, Rachel Carson wrote of a silent spring, and used data on dying songbirds to help sound her alarm about our indiscriminate use of pesticides. But for many that was a tough pulse to put a finger on. Spring did not go silent, after all, and there were still rails and nuthatches and thrushes to be seen by the active birder. But Ospreys and other large birds of prey were a bigger alarm bell, an easier target for researchers and the general public to study and see.

Roger Tory Peterson, the great US naturalist, bird painter, and author of field guides, made his home along the banks of the Connecticut River estuary in part because dozens of Ospreys nested within sight of his house. Ospreys were his favorite bird. Stepping out his door one July afternoon in the late 1950s, Roger scanned nests on the marshes below him and noticed they were largely empty of young, at a time of year when fledgling Ospreys should have been very much in evidence. His alarm at that finding spawned a series of studies on those Ospreys and others—studies that helped bring DDT's widespread impact on Ospreys and their eggs into the spotlight and helped lead to the eventual ban of that pesticide in North America. A quick glance was all it took for a knowledgeable naturalist to notice something amiss. With a bird of lesser stature, more dispersed and hidden and less numerous, all this might have been missed or gone undetected for longer.

Generating human interest has played a big part in the Osprey rescue mission of the past fifty years. And it's unlikely this interest will wane in the years ahead. Nest platforms, and the build-up of a loyal base of interest in the species, have all made populations easier to monitor, creating a positive feedback loop: more Ospreys, better monitored, and thus a better gauge of the species in different parts of its range.

Keep in mind too that nesting Ospreys can bring significant economic benefits to a community. Recently, a single pioneering nest in Cumbria, UK, has been estimated to generate two million pounds ($2,563,000 US) a year for the local economy, thanks to the steady stream of tourists it pulls in. Admittedly this is a new nest in an area that has long been without Ospreys in a nation that is crazy about wild birds, but it does show how charismatic wildlife can help generate significant cash. At the Loch Garten nature reserve in Scotland, well over a million visitors have made the trek over fifty years to see a single Osprey nest. Clearly those are Ospreys that have been earning their keep! Finland has done almost as well with its Pohtiolampi Osprey Center, so one can't help but see these as models for

Ospreys are introduced to a school in Senegal, West Africa, via the internet. This program, sponsored by England's Rutland Water Osprey Group, targets schools in regions of West Africa where European Ospreys winter, helping to tell the story of Osprey migration and linking schools in the United Kingdom and Africa.

other regions where Ospreys have settled, bringing about a chance to promote the species and its conservation, and to educate people about the links between Ospreys and the ecosystems that support them. Surely there is room for new Osprey centers in other parts of the world.

Nowhere has the educational potential of having Ospreys in the neighborhood been better realized than in England. Centered at the Rutland Water Nature Reserve, creative efforts to develop an ecological curriculum based on Ospreys have taken off, with outreach on the web and even to classrooms in areas where Ospreys winter in West Africa. Here again we find a model for educational outreach.

And the webcams springing up at Osprey nest sites across Europe and North America are an educational resource waiting to be tapped. Websites with chat room sessions led by experienced researchers are an ideal way to bring keen birders and naturalists, as well as students with little exposure to the natural world, up to speed on the excitement and wonders to be found in time spent watching an Osprey nest.

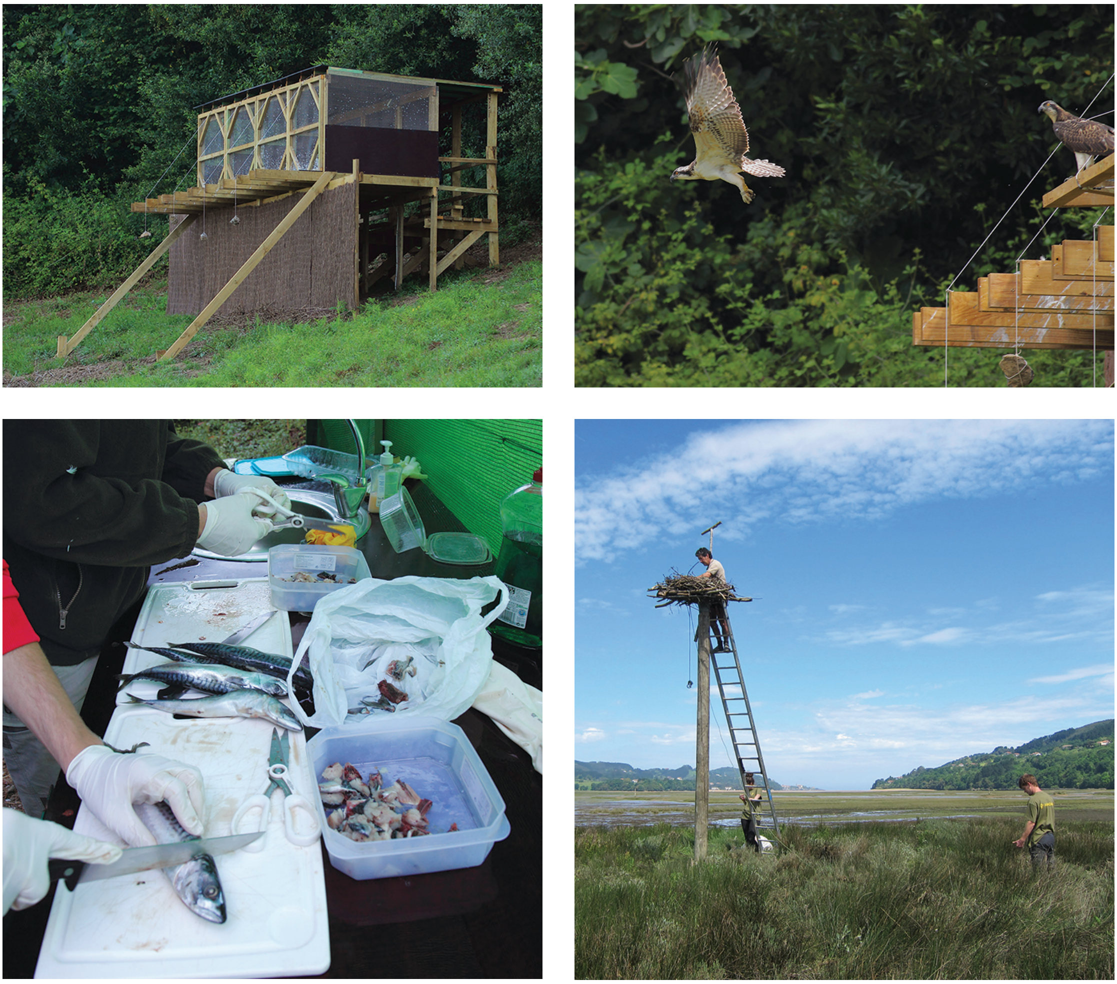
With over five hundred Ospreys that have now been tagged with satellite or cell-tower transmitters worldwide, a wealth of migration information is waiting to be plugged into educational programs. While the Rutland Water crew has pulled the lid off some of this, the vast majority of those migration and wintering data await serious effort to bring them to light. Collaborating with educators to create a vibrant story around Osprey migration, and the ecology that supports it, would be a challenge worthy of the extraordinary effort that has gone into gathering that information.

RESEEDING: TRANSLOCATIONS, REINTRODUCTIONS, AND RECOVERY

It's tough to argue with success. As we look back on the last fifty years of Osprey management, and then ahead to what Osprey populations of 2050 or 2100 might look like, we have to admit there's one path that has been clearly marked. Ospreys take remarkably well to reintroductions—moving young from nests in areas with robust populations to regions where the species has been wiped out or much reduced. Once moved, they are fed and cared for by a team of researchers and allowed to fledge at the new site, gradually imprinting on that area before they leave in migration. These Osprey "hacking" techniques were perfected alongside those with other birds of prey. At least two decades (1970s and 1980s) of moving Ospreys into vacant inland waters of the United States proved how well this bird responds to these methods. Well-established US nesting populations now exist in such states as Tennessee, Pennsylvania, Minnesota, and Iowa—all regions once lacking Ospreys. Programs to reintroduce them showed that such efforts make a big difference. And more recently, Rutland Water's success in bringing Ospreys back to the Midlands of England has helped launch reintroduction efforts in other parts of Europe. Over 100 young Ospreys have fledged from Rutland Water nests in the past 15 years, bringing a solid breeding population of Ospreys back to England for the first time in 150 years and generating great excitement. Think of this as spreading seeds—a few dozen young Ospreys released into a region imprint on those surroundings and then return to start a new population, often attracting others to join them as mates.

There are good reasons to continue these efforts. Ospreys, as we have seen, are slow to disperse. As first-time breeders, individual birds tend to settle near their natal site, so it can be a long wait before the species pioneers new areas or recolonizes long-abandoned breeding grounds. Recent efforts to restore populations through hacking programs have centered on southern Europe—Spain, Portugal, and Italy—all regions with Osprey populations that were historically viable but sadly reduced or extirpated by the early twenty-first century. Spain has led the way here, with over 150 young from Finland, Scotland, and Germany released in 2003–12, all in all a model project.

Burrowing into this project's reports one sees the extraordinary effort and attention to detail that's required to make such efforts happen—to find young Ospreys in their donor nests in the north, secure the necessary permits, fly them south to specially built hacking cages, net and prepare fresh fish to feed them several times a day, and monitor their every move via closed-circuit television. It takes a competent team and significant funding to make this happen. Finally, the



Top left: An Osprey release site in the Basque country of northern Spain, where a program to reintroduce the species has been underway since 2013. This structure houses and protects the fledgling Ospreys, imported mostly from Scotland, while they complete their growth. *Top right:* Once the young can fly, they are allowed to come and go from their chambers but continue to be fed there. *Bottom left:* Fledgling Ospreys in these reintroduction programs must be fed; here we see Basque researchers preparing fish to be dropped into the chambers that house the young. *Bottom right:* Building nest sites on Basque wetlands to encourage the settlement of released Ospreys when they return at breeding age.

fledglings are color banded so they can be identified when they return. Spain's breeding population is now growing exponentially, thanks to introduced Ospreys that have come "home to roost," with over thirty active nests in 2016, split between fresh waters (mostly reservoirs) and saltwater coastal areas.

Despite such success, there are some, including a few of my distinguished colleagues in the Osprey research world, who argue against such efforts. "Let the Ospreys establish new populations on their own," they say; no reason to go to the time, trouble, and expense to reintroduce them into new regions they once called home. I respectfully disagree, at the same time noting that most of these detractors live in areas of northern Europe where they have plenty of Ospreys around them. One has to wonder if they wouldn't change their tune if forced to live where the only Ospreys to be seen were in dusty paintings hanging on walls, a sad reminder of what used to be. I have great respect for what Osprey reintroduction programs have accomplished and great faith in what lies ahead for them.

But I can envision refining the approach, making it more surgical to target areas within countries with recovering populations, areas that the birds have not yet found but that have significant potential for growing numbers. Coastal regions of Europe are ripe for new recruits. Remember that Europe's coastlines are largely barren of nesting Ospreys; it's almost entirely a freshwater species there. A handful of modest translocation projects—hacking out a few dozen fledglings in appropriate coastal areas, especially on the extensive marshlands of France and England (perhaps Ireland as well)—combined with building artificial nest sites to hold the birds when they return, could help stabilize and diversify these growing populations. Such efforts are just getting underway along the south coast of England, at Poole Harbor (no relation, that I am aware of!) in Dorset. It will be fascinating to see how this pioneering project takes off. For those who worry about the cost and effort of such projects, we can remind them of that nest in Cumbria that has been generating millions of pounds a year. But it is more than money to be gained here—a lot more. The joys of having Ospreys as part of a local landscape cannot be easily measured.

THE KNOWLEDGE GAPS: WHAT DO WE STILL NEED TO LEARN?

While Ospreys are exceptionally well studied compared to most of the world's birds—a tribute to their charisma, accessibility, and widespread distribution—there are still many populations, and surprising portions of the Osprey's life, that remain poorly known. Most Osprey studies have focused on northern breeding populations. Caribbean, Middle Eastern, Asian, and even Australian Ospreys have been neglected by comparison, particularly in recent decades. Japanese Ospreys, especially in southern reaches of that island nation, are particularly ripe for study—how many remain, where they nest, how they integrate into a nation of people that rely so heavily on fish, and if and where they migrate. Ospreys nesting in the vast forests of central and eastern Russia remain equally mysterious, especially in regard to population size. In the Caribbean, nesting populations in Cuba are one of the black holes of the American Osprey scene. And Middle Eastern coastlines, which have supported surprisingly robust Osprey numbers through the end of the twentieth century, now seem more vulnerable owing to development and political instability in that region, with unknown consequences for the Ospreys and other water birds that depend on those fragile habitats.

Roy Dennis

BRINGING OSPREYS BACK TO EUROPE

It is hard to think of another person who has done more than Roy Dennis to bring the Ospreys of Europe, and especially the United Kingdom, from the dark era of egg thieves and shooting and neglect into the enlightened conservation era of today. Rooted in the Highlands of Scotland, where he has spent most of his life, Roy first encountered Ospreys in 1960 when he was appointed warden at the pioneering and now-famous Loch Garten nest, in Strathspay, northern Scotland. Those early years were crucial for the recovery of Ospreys in that region, and Roy was a leader in getting new nests established there, and in helping to develop the Loch Garten Osprey Center into the mecca for natural history tourism that it has become.

All this took place under the banner of the Royal Society for the Protection of Birds (RSPB), where Roy was employed for two decades, eventually as director of their Highlands office, with Ospreys very much on his radar in that post. From the RSPB, Roy went on to start his own wildlife consulting business in 1991, but never stopped developing the networks of supportive people that proved so important in nurturing the recovery of Scottish Ospreys. Talk to anyone involved with wildlife today in Scotland—gamekeepers, foresters, farmers, or estate owners. It is hard to find a person in that world who doesn't know Roy and have the utmost respect for his work.

But tellingly Roy was never content to rest on his Scottish laurels. His vision has always been for a Europe with Ospreys (and other key wildlife) restored to areas where they thrived years ago. He was a key advisor in the effort to bring Ospreys back to the Midlands of England (Rutland Water), and likewise helped launch similar reintroduction efforts in Italy, Spain, Portugal, and most recently Switzerland. This often meant bucking tides of criticism, for many felt it was better to let nature take its own course, and that money spent moving Ospreys should be used to protect those already established. But the success of Roy's efforts, continued by his many collaborators, is a convincing argument that reestablished populations really are worth the time and money involved. Having Ospreys back on the map has been a source of enormous pride for

Surveying the scientific literature on Ospreys, one sees that in the last forty years roughly 30% of the papers written on the species have focused on diet, with another 30% covering levels of contaminants in eggs and tissue. All of this is valuable information, but such a focus means that big gaps remain in our understanding of the species. So while we know a lot about what Ospreys eat in different parts of the globe, we know much less about how and where they catch their fish—their foraging strategies. To help us answer that question, data from satellite-tagged males during the breeding season are increasingly available but have yet to be thoroughly analyzed. And efforts to target males from populations where foraging locations remain unknown could prove especially useful.

In addition, we still have a lot to learn about the population biology of Ospreys. Pioneering studies by C. J. Henny, Paul Spitzer, and Sergej Postupalsky

local residents and all involved, and a beacon of hope that past destruction can be reversed.

Throughout his career, Roy has been tireless in promoting an understanding of wildlife to the public—as a presenter of films for the BBC and with instructive books, including his charming *A Life of Ospreys*. He has won numerous awards from zoological societies and ornithological groups in the UK, and was even recognized by the British Crown with an MBE (Member of the Most Excellent Order of the British Empire). Clearly, Ospreys did well to have Roy Dennis on their side.

opened doors to this topic in the 1970s and 1980s, with follow-up studies in Sweden and France a decade later, but much has changed since then, especially Osprey numbers and density. We need studies on newer, more crowded populations in different parts of the world, to see how breeding success, dispersal, age at first breeding, and survival change as populations grow. And we know nothing about the dynamics of nonmigratory Osprey populations. It seems likely these birds have very different constraints on their numbers than their northern counterparts do. All such studies rely on extensive color banding of breeding individuals, focused in areas where they can be followed over years or lifetimes—a significant commitment of time and energy. But the rewards of such efforts are great.

And we can't help but think of the "data troves" that exist for Ospreys, those extraordinarily detailed collections of information from the hundreds of

Finding a safe landing. The odds seem good that most Ospreys will continue to do this in the years ahead. Connecticut, USA.

individuals that have been tracked by satellite transmitters, as well as the dozens of Osprey pairs whose reproductive lives have been recorded season after season at nests with webcams. Combined, these sources hold enough data to keep a team of graduate students working for years. What's needed here is to target studies that would shed light on topics we know the least about: rates of fish delivery in relation to weather; food sharing at nests; how young birds find a nest and mate, and integrate into new populations; and seasonal changes in diet—to name just a few.

Although the data have yet to be carefully analyzed, we are seeing one research intrusion that may have negative impacts on Ospreys: satellite transmitters. This needs to be studied more carefully. What is confusing is that at least some of the birds wearing transmitters seem to behave normally. They migrate on schedule to traditional wintering grounds and return to nests and raise young the following year, just like their neighbors that are not wearing transmitters. But others, and there are many of them, seem to be compromised. Among adult males fitted with transmitters in New England, for instance, only a few raised young to fledging in the year they were tagged; most of their nests failed. And among all adult Ospreys tagged in the United States, 44% died before completing their first migration cycle—mortality rates much higher than average for adults of the species. Juvenile US Ospreys wearing transmitters fared even worse—only 12% survived to return to breeding grounds. This is not to say that satellite tagging hasn't been worthwhile. We have learned a tremendous amount from this technology that has been and will be of value to Osprey conservation. But it looks as if this knowledge may have come at a price.

And finally, when looking at gaps in knowledge, we have to acknowledge that overall the Osprey story is one we wish people knew better. My hope is that this book will help in that mission. While there are pockets of the world where the species is well recognized, even revered, overall its history and the lessons it has to teach us are sadly missing from our cultural legacy. As a new generation comes of age that is increasingly divorced from the natural world, Ospreys offer a door—and an exciting one—back into ecological literacy. They have an important story to tell—of our capacity to learn from mistakes and regroup for a more sustainable world; of how continents and cultures are linked by bird migration; and of the magic of having a global citizen, a large wild bird of prey, living in our midst.

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